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Water supply issues in the Valle de Mexico: User side perceptions

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Water supply issues in the Valle de Mexico: User side perceptions

by

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Dedication

Dedicado a las personas que forman parte de mi equipo en este caminar que es la vida buscando cumplir sueños en realidades. A ellos que nunca han bajado los brazos, que han estado a mi lado en cada paso y que con su cariño y presencia me han transformado en lo que soy hoy en día.

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Hace ya unos años apunté a una estrella soñando en siquiera alcanzar el cielo; hoy desde esa estrella apunto hacia el siguiente sueño.

Abstract

Water supply issues in the Valle de Mexico: User side perceptions

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Mexico's center territory, Valle de Mexico, is the most populated and developed area in the country. Although it is also the wealthiest area of the country, its unreasonable size gives rise to issues that require prompt attention. The problem of supplying water to the urban region of Mexico City and the metropolitan area is extremely complex due to the interconnection it has with different factors such as public affairs, social conflicts, consequences for the environment, energy – water nexus, economic investments, among others. This research evaluates the problem of water supply by examining the key driving forces that impact reliability of the supply as perceived by residents. A literature review revealed that the water crisis in the region is closely coupled with many social and economic issues. Energy-water nexus connections are a significant driver in water governance activities because the majority of water agency budgets, estimated to be 80%, is directed to electric bills rather than mitigation, monitoring or maintenance. Yet these relationships are based on limited information from the field and, therefore this study takes initial steps to fill the gap in knowledge about water supply conditions by collecting ground

truth data related to the observations and perceptions of resident via interviews and surveys. Results of surveys and responses from approximately 192 participants completed between July and August 2017 indicate that there are two different categories of water shortage in the Valle de Mexico. The first is related to non-mitigation of infrastructure failures, such as leaks and broken pipes, while the second is that water users do not conserve the resource when it is available. Interestingly, the second type of water shortage is exacerbated by the beliefs and perceptions of residents in the region because their behaviors reflect a pattern of overconsumption when water is present in the system. The result is an increase in periods without water supply in the system driven purely by use patterns. This result highlights the urgent need to better understand the mindset of users to guide future urban development. Improving understanding about the drivers behind water scarcity in the Valle de Mexico is useful in relation to the water sector, as well as all of the other sectors and aspects that will negatively impact the lives of residents. All the inhabitants of Mexico, regardless of their actual role, must become primary actors working together on this complex and often intimidating issue.

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Chapter 1: Introduction

Mexico City's metropolitan area, Valle de Mexico, has almost 23 million inhabitants (INEGI, 2015) and consists of the political capital of the country along with 18 additional municipalities of Mexico State (Figure 1-1). As Jazcilevich Diamant (2015) states, this area represents the most important cultural, financial, and economic center nationwide. Promoting economic development in this region is strategic for the country and calls for a sustainable approach. Decisions must be made in order to address the complex difficulties in an efficient manner. Today these problems include various environmental issues such as mitigation the effects of climate change, sufficient generation of energy, sufficient water supply for the population, flood mitigation, and the reduction of air and water pollution. At the same time the consequences of large human settlements are expected to grow and the economic activity to increase creating aridification unless a sustainable approach is followed.

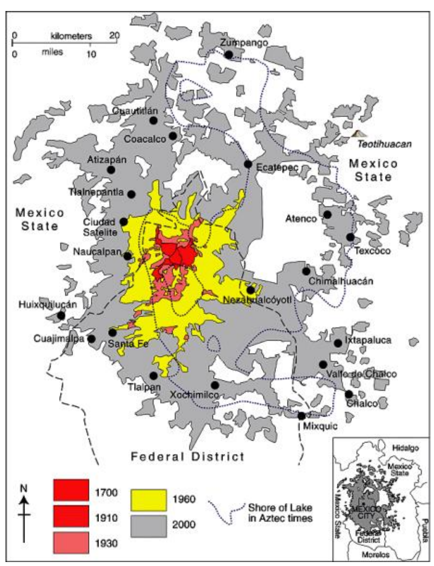

Figure 1-1: Valle de Mexico (Rhoda & Burton, 2013)

CONAGUA (2013) states that the problems related to drinking water and efficient drainage systems are not new in this area, but they have been aggravated by poorly planned growth of the metropolis during the second half of the last century and the constant ground subsidence. Another problem is the pollution of rivers in the region, most of which are contaminated with untreated wastewater discharge. System reservoirs have suffered deterioration in water quality as a result of deforestation, the expansion of the agriculture, improper conservation of soil and water practices, and the urban and rural growth of population without adequate sewerage and residual water treatment.

GEOLOGY OF VALLE DE MEXICO

Mexico City metropolitan area is located in the Mexico's Basin (Figure 1-2) an endorheic basin with a lacustrine character (CONAGUA, 2013). It has an approximate area of 9,540 km^2 of which the Valle de Mexico occupies about 65%. The average height of the basin is 2,240 m above sea level (Escolero, Morales-Casique, & Arce, 2015). The region has been exposed to stress and volcanic activity that has produced an area full of faults. The region was covered by several lacustrine areas that formed at the end of the last glacial period when the basin was closed (CONAGUA, 2015) during the Late Quaternary. González Torres, et.al. (2015) mentions that the city is located in the central-east portion of the TransMexican Volcanic Belt. The lake plateau is bounded by four mountain ranges of volcanic origin: the Sierra Chihinautzin to the south, the Sierra de las Cruces to the west, the Sierra Nevada to the east, and the Sierra de Pachuca and Tezonatlalpan to the north (González Torres, Morán Zenteno, Mori, & Martiny, 2015). The irregular contour of Mexico's Basin is elongated from north to south, with a large extension to the northeast. Its major axis is approximately 110 km and its minor axis reaches 80 km (CONAGUA, 2015).

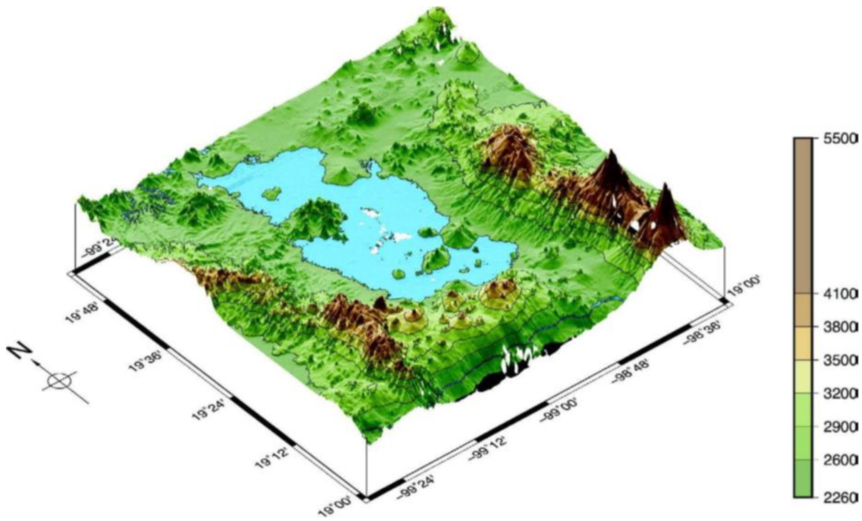

Figure 1-2: Mexico's Basin. (CONAGUA, 2013)

Mexico's Basin is a deep depression that originated in response to the volcanic and tectonic activity in the region. The basin has several faults caused by tectonic movements and volcanic activity (Figure 3). Six deep boreholes have been drilled in different parts of the basin in order to obtain the stratigraphy of the area and relate the magmatic province to the Sierra Madre del Sur (González Torres, Morán Zenteno, Mori, & Martiny, 2015). The original structural relief is closely related to intense volcanic activity that began in the early Tertiary Period and developed during the Early Pleistocene. The evolution of volcanic activity led to the formation of an endorheic basins that was later filled with volcanoclastic materials, and volcanic rocks deposited within a lacustrine environment. Their former levels are observed as flat relics in flat as plateaus (CONAGUA, 2013). Lacustrine sedimentary sequences are natural records of climate and environmental changes. Active volcanic and tectonic environments like this may also influence lacustrine sedimentation. The Valle de Mexico, has a high rate of subsidence that in average excel 350 millimeters per year (Cabral-Cano et al., 2008; Ortega Guerrero, Lozano Garcia, Caballero, & Herrera Hernandez, 2015).

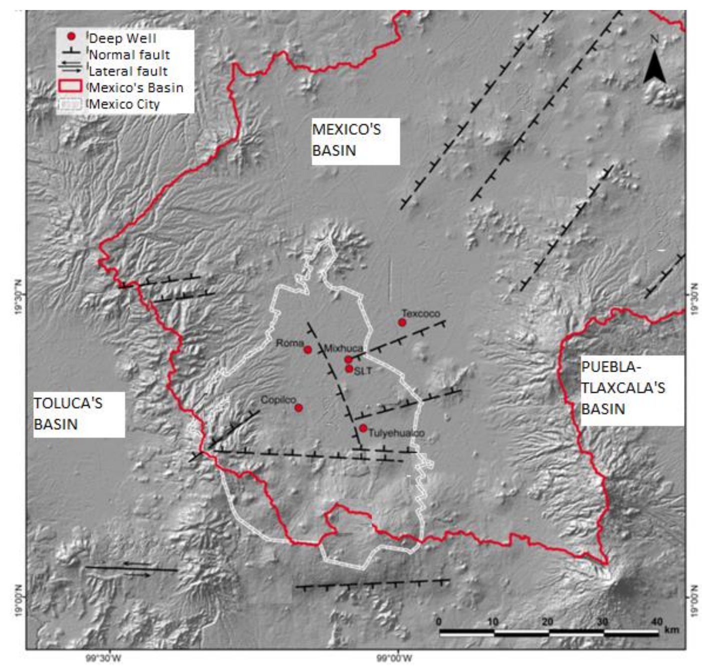

Figure 1-3: Faults on the Mexico Basin and wells that have been drilled. (González Torres, Morán Zenteno, Mori, & Martiny, 2015)

This endorheic basin was modified in the mid XVIII century when construction of a canal was started in order to connect the city with the Tula River and to provide artificial drainage for the basin that would prevent its recurrent flooding Subsequently, in the intervening centuries it has been supplemented with several tunnels, changing the hydrological regime completely. This infrastructure was needed because the city flooded often due to the fact that there was no natural drainage (CONAGUA, 2013).

OVERVIEW OF THE CHALLENGES IN THE WATER SUPPLY SYSTEM

The biggest challenge that Mexico City's metropolitan area has is its population growth. This region has seen an inordinate increase in its population in the last 65 years

(CONAGUA, 2013). In 1950 it had 3.3 million inhabitants and now, in 2017, there are more than 23 million. The consequences of this growth include the drying of lakes, deforestation, overexploitation of aquifers, subsidence, deterioration of water quality, and increased risk of flooding in rainy seasons. Related to water, the main challenge is to provide safe access to clean water to the population of the region. Currently, there are three major water sources that are responsible for the water supply: Cutzamala, system, Lerma system, and the underlying aquifer (Figure 1-4). To date, planning efforts have been inadequate, and more water is extracted from these sources than is being recharged, resulting in a dramatic decrease in water resources. (CONAGUA, 2013)

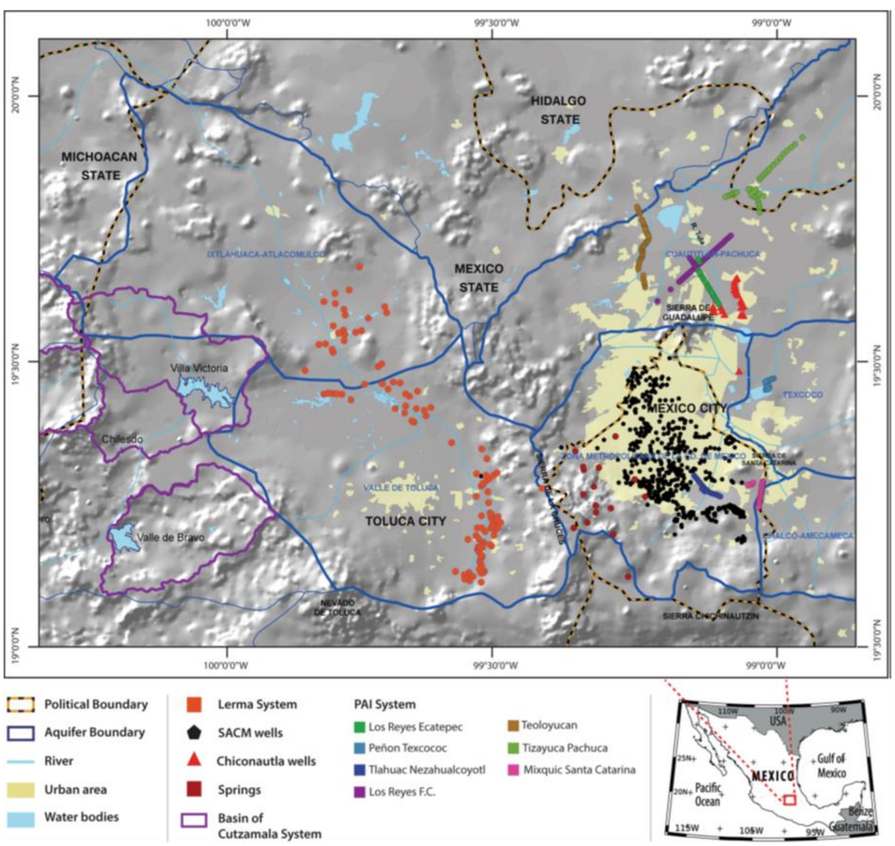

Figure 1-4: Locations of aquifers and drinking water supply systems for Mexico City and its metropolitan area (Martinez, Escolero, & Perevochtchikova, 2015).

The water supply for the Valle de Mexico is calculated to be ~83 m^3/s, although this data is uncertain due to lack of better information. Two manmade systems, Cutzamala and Lerma, are responsible for almost 23% of the total water supply to the Valle de Mexico. The other 77% comes directly from the aquifer that is below the region (Rhoda & Burton, 2013).

Manmade systems: Cutzamala and Lerma

The Cutzamala system is the most important supply of surface water to the Valle of Mexico. This system is also considered one of Mexico’s most ambitious engineering works. Beginning in 1982, it was initially designed to carry 4 m^3/s from the Villa Victoria dam to Mexico City by a 13 km long aqueduct. Today, after two major upgrades, this system has the capacity to provide up to 19 m^3/s but only supplies 14 m^3/s to the Valle de Mexico, and the rest goes to other locations. The system has two further installments, one of 5 m^3/s for the State of Mexico, and the remaining 9 m^3/s are delivered to Mexico City. The water in the current design system travels through more than 150 km (SEMARNAT & CONAGUA, 2013).

The Cutzamala system provides water to 11 municipalities in Mexico City and 11 more in Mexico State. In order to supply the water, this system has to overcome a 1,100 m difference in elevation between the lowest elevation of the water source and the consumer location (Figure 1-5). This system is composed of 7 dams that work as reservoirs, 6 major pumping stations, and a single water treatment plant. These dams are located in 7 sub-basins: Tuxpan, El Bosque, Villa Victoria, Valle de Bravo, Ixtapan del Oro, Chilesdo, and Colorines (Rhoda & Burton, 2013).

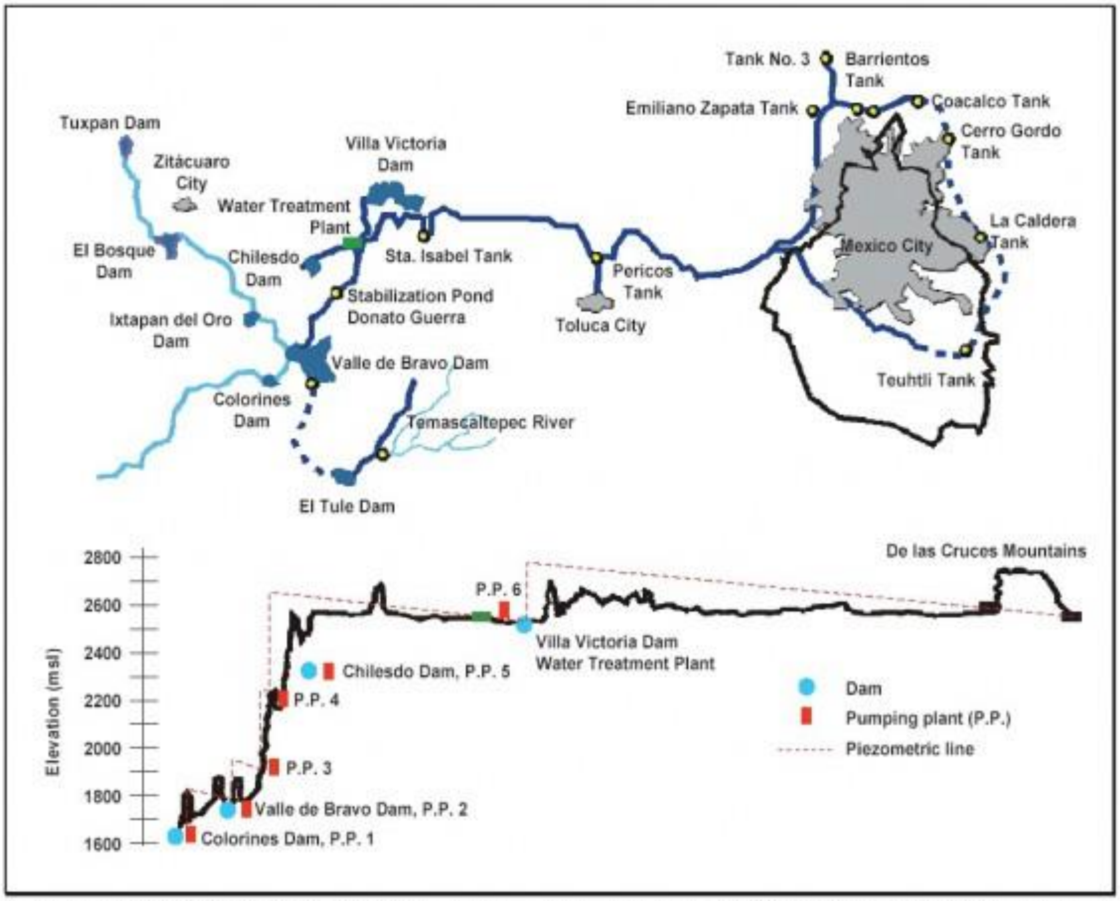

Figure 1-5: Cutzamala scheme (Rhoda & Burton, 2013)

Water of all seven input sources of the Cutzamala system has been deteriorating. This is due to deforestation, the expansion of the agricultural frontier without proper conservation of soil and water practices, and the growth of urban and rural populations without adequate sewage and water treatment. If no solutions are implemented, there is a risk that water will continue to decrease its quality and additional water treatment will be required, this increasing the water supply costs (CONAGUA, 2013).

The Lerma system is located in the Lerma-Chapala Basin (Figure 1-6). It is the largest and the most important river system in Mexico reaching 5 states. This basin is a critical component of the Mexican economy with a GDP of $80 billion dollars per year and 10% of the total country's population. Mexico's largest natural lake, Chapala, is also located in this basin, and the river system connects with the Cutzamala system, creating the Lerma-Cutzamala system. (Rhoda & Burton, 2014)

Prior to the creation of the Cutzamala system, the Lerma system was the only external source of water for the Valle de Mexico since it opened in 1942. Today it has 398 interconnected active wells to supply water to Mexico City and its metropolitan area. The system has a capacity of 15 m^3/s, out of which 4.8 m^3/s are currently used for the Valle de Mexico. The Lerma system suffered the consequences of aquifer exploitation in the area. Some of these have been the negative impacts of wetlands flora and fauna declared by UNESCO as protected areas, and the cracking and ground subsidence since the 1970s (Escolero, Martínez, Kralisch, & Perevochtchikova, 2009).

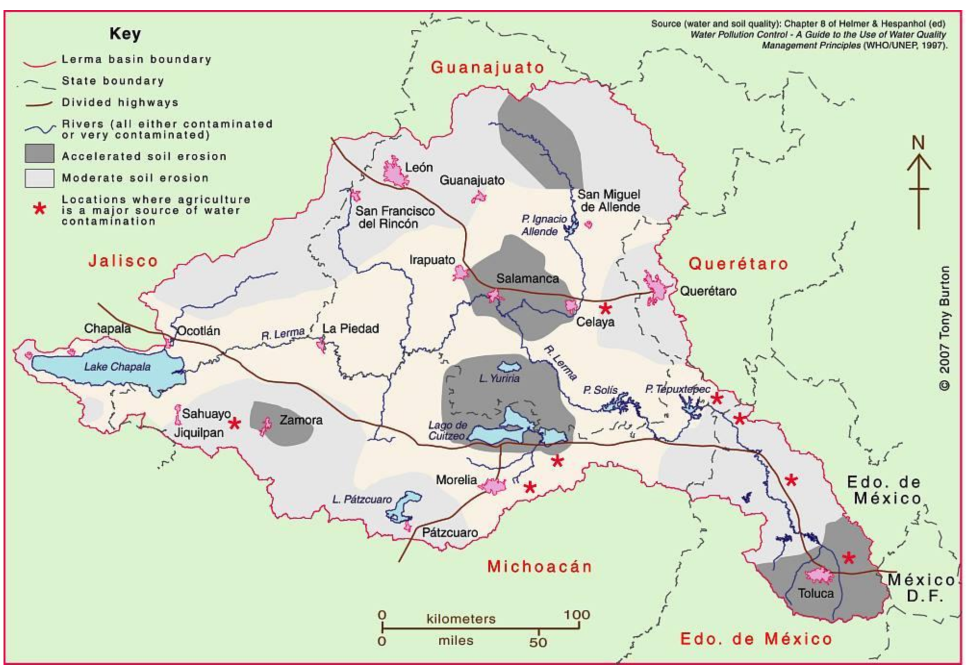

Figure 1-6: Lerma Basin (Rhoda & Burton, 2014).

Groundwater source: aquifer

The Valle de Mexico aquifer supplies 77% of the water used by the city, making it the most important water source (CONAGUA, 2013). There are over 549 water wells ranging between 30 and 1,300 m deep. There are two ways in which the water is extracted from the aquifer: PAI wells (Spanish acronym for Immediate Action Wells) and the regular extraction wells. Of these, 218 are PAI wells that are located throughout the city and are used only in case of emergency, providing a quick supply in case of water shortage. Currently all the combined wells provide 64 m^3/s of water to the Valle de Mexico.

As shown in Figure 1-4, there are several aquifers that supply water to the metropolitan area, and because they are interconnected, water pumping in Mexico City affects the water level in aquifers used by neighboring areas. Currently more water is extracted from the aquifers than is recharged, resulting in land subsidence of the Valley of Mexico (Escolero, Martínez, Kralisch, & Perevochtchikova, 2009). In 2010 CONAGUA estimated that by 2015, 37% more water would be extracted from the aquifer than it would be recharged. But in fact by 2015 there was a difference of 115%, where the water supply system extracted 2.15 m^3 for each m^3 recharged (CONAGUA, 2015).

RESEARCH STRATEGY AND APPROACH BY CHAPTER

This thesis is a combination of technical background and the opinions and points of view of the water users in the Valle de Mexico. The brief description of chapter contents that follows is provided to give the reader and overview of the format sequence that the different components are presented.

Chapter 2: A 360° Interdisciplinary Overview

Water supply is a highly connected process that interacts with different areas such as environmental, public health, anthropological, economical, public affairs, technical, energy, and infrastructure issues. In order to understand the complexity of the water supply issue, a synopsis of the different connections are shown.

Chapter 3: Water – Energy Nexus in the metropolitan area

Energy is a big component of the water supply issue in Mexico City and its metropolitan area. In this chapter, an overview is presented of the water-energy nexus and what are the main challenges in this area that contribute to the water supply system.

Chapter 4: Methodology

This study presents results based largely on data collected through interviews and surveys completed with water users in the Valle de Mexico. This chapter describes methodology used to conduct and complete surveys and interviews.

Chapter 5: Results

Analyses and observations of the results from interviews and the surveys are presented.

Chapter 6: Analysis

An analysis is made using the results from the previous chapter and including inputs of technical information found through research of official or respected sources.

Chapter 7: Conclusions

Finally, a conclusion of what it is observed is presented. Also in this chapter several further actions are proposed that would continue the research in this topic and which are beyond the scope of this work.

Chapter 2: A 360° Interdisciplinary Overview

The growth of Mexico City and its metropolitan area has been extensively evaluated in the context of rapid urbanization and creation of megacities in developing countries. The Valle de Mexico has not only experienced significant environmental changes due to its population growth, but also because of the accelerated urban and industrial development without a proper resource management. Uncontrolled water extraction and use, poorly managed delivery, infrastructure with limited maintenance have been the key driving forces behind the urban water consumption problem. Because of this, it is important to see how the issue of water supply is connected to environmental, public health, anthropological, economical, public affairs, technical, energy and infrastructure issues (Martinez, Escolero, & Perevochtchikova, 2015).

ANTHROPOLOGICAL ISSUES

In Mexico, the geographic distribution of water consumption does not match the distribution of its urban settlements. Approximately 27% of the total population is concentrated in the central-north portion of the country. This population generates 79% of the GDP but only has 32% of water sources (Escolero, Martínez, Kralisch, & Perevochtchikova, 2009). Inadequate water planning in the Valle de Mexico not only impacts urban residents, but also other communities that live nearby. Most of the people in these rural areas are dedicated to agriculture and have been affected by the loss of water and productive agricultural land. Some people have been forced to use wastewater without any treatment to irrigate their crops, thus contaminating their products (Delgado-Ramos, 2015). The Mazahua community near the Villa Victory dam, (part of the Cutzamala system) has reported that 8 out of 10 families do not have access to tap water and that the water supply is below the water quality standards that are allowed for human consumption (Escolero, Martínez, Kralisch, & Perevochtchikova, 2009).

Delgado-Ramos (2015) argues that transforming urban settlements in developed countries is more feasible than in developing countries; not only because they have greater means of economic and technological innovation, but also because many hidden or indirect socio-environmental and climate costs are “exported” or internationalized. Therefore, urbanization in developing countries tend to be more problematic and complex due to a limited capacity to take measures and actions, a scenario in which urban poverty is an enormous challenge to developing a more human and sustainable urban configuration.

Water sources, such as lakes, rivers, or dams, sometimes have additional uses. Both, Lerma and Cutzamala, have important cultural and tourism sites. For example, the Chapala Lake in the Lerma system is not only the largest lake in the country, but also the most important as far as tourism is concerned. Here, endemic species of flora and fauna, draw tourists who can horse-back ride, hike, and tour the lake by canoe or boat. Also located in the Lerma Basin is the Patzcuaro Lake, an important location for the November 1-2, Day of the Dead festivities (Figure 2-1). Every year, people from the region decorate and create *ofrendas* for their dead relatives to honor them and welcome them. Thousands of tourists, from all around the world, visit this area because of the importance of this tradition in the Mexican culture. Finally, it is important to mention the case of Valle de Bravo. This reservoir was first constructed as a hydropower dam that would not only help supply water to the Valle de Mexico, but also provided electricity to that area. As tourism started to increase in this region, the dam had to stop the hydro-electrical operations to become a place where modern water sports, such as windsurfing, water-skiing, and yachting, can be enjoyed. These few examples are important to highlight the importance of tourism for the area, but also, how water supply is engaged in many other ways to the society and its economy. Tourism does not only affect the water supply in the area of active tour activities, but there is also an impact on cities in the same region that rely on the same water supply sources. (Rhoda & Burton, 2013)

Figure 2-1: Day of the Dean in the Patzcuaro Lake (Allianz, 2017).

PUBLIC AFFAIR ISSUES

In Mexico, both federal and local governments are responsible for the development and management of the water supply system in Mexico City, and the water quality of supply. Control measures are being implemented to reduce the negative impacts and although they have had some success at a local scale, challenges continue to exist at the federal level because water challenges continually develop and appear at new sites. The complexity of the water supply system in the Valle de Mexico, and the overlap in responsibilities between federal and local authorities constrain efforts toward regional management of the water resources. There is a need for innovative management approaches from the perspective of shared water resources and the exchange of information between different agencies facing common problems (Martinez, Escolero, & Perevochtchikova, 2015).

In Mexico, since 1992, the Federal Congress passed the National Water Law. It establishes broad objectives for the development and implementation of plans and policies related to the management of water resources. In this law, special attention is given to water quality, both for the purpose of protecting human health and preserving or improving hydro systems. In an effort to preserve aquifers, one of the most important articles is number 39 that indicates that the President may issue decrees for the establishment of veto for the exploitation or use of national waters. This may only apply when there is no chance of maintaining or increasing the actual water extraction rate without affecting the sustainability of the resource and without having harmful economic and environmental consequences. (SEMARNAT, 2013)

On October 2017, President Enrique Peña Nieto inaugurated a system of deep wells called "Sistema de Pozos Profundos" which have the goal to supply water for the Mexico city population to avoid further subsidence in the region. This system consists of four wells of more than 2 km deep with an estimated an investment of $ 3 million US dollars. The government assures that this system in addition to the water recharge program will help maintain the shallow aquifer (which is the only one that has been exploited until now) and will help decrease the dramatic subsidence rates (Presidencia de la República, 2017).

ECONOMIC ISSUES

Water is considered a human right in Mexico. Because of this consideration, the government subsidizes more than 50% of the real cost of the water supply process. The operation of supplying the population with water is carried out in a systematic way by the Organismo de Cuenca de Aguas del Valle de México (OCAVM). Each year, the OCAVM has an authorized budget that comes from the federal budget. Part of the money is used in operation, maintenance, conservation of the hydraulic infrastructure, and water treatment process; however, most of the budget (80%) is spent on the electric energy consumption for the operation of the Cutzamala system, Lerma system, and exploitation of the aquifer (SEMARNAT, 2013)

Table 2-1 presents the average bi-monthly rate for water that the inhabitants in the Valle de Mexico pay. It is worth mentioning, that these costs are shown without factoring in any subsidy, but in reality, the users pay only ~50% of the real cost due to subsidies. The water rates are divided in tiers depending of the consumption of water of the household and the socioeconomic classification of the area where they are located (i.e "popular", "low", "medium", "high"). Although there should be some elasticity on the price of water, in the case of Mexico, calculating it is a great challenge because the minimum wage is of $4.70 dollars per day (Gillespie, 2017). The Operating Expense (OPEX) for water supply to the Valle de Mexico is above $130 million dollars per year, mainly because of the energy needed to pump the water to an altitude difference of more than 1,000 m. To put that in context, that energy is the same one that the city of Puebla consumes in a year with its 8.3 million inhabitants (García, 2016).

m3 consumption		"Popular"		"Low"		"Medium"		"High"	
Inferior Limit	Superior Limit	Minimum Cost ($ dollars)	Additional cost per m3 over the inferior limit ($ dollars)	Minimum Cost ($ dollars)	Additional cost per m3 over the inferior limit ($ dollars)	Minimum Cost ($ dollars)	Additional cost per m3 over the inferior limit ($ dollars)	Minimum Cost ($ dollars)	Additional cost per m3 over the inferior limit ($ dollars)
0	15	$1.94	$0.00	$2.21	$0.00	$7.31	$0.00	$8.77	$0.00
Above 15	20	$1.94	$0.17	$2.21	$0.38	$7.31	$0.94	$8.77	$0.99
Above 20	30	$2.79	$0.27	$4.09	$0.51	$12.01	$1.03	$13.70	$1.10
Above 30	40	$5.47	$0.55	$9.16	$0.72	$22.32	$1.22	$24.73	$1.31
Above 40	50	$10.92	$0.80	$16.34	$1.01	$34.51	$1.31	$37.81	$1.40
Above 50	70	$18.89	$1.19	$26.42	$1.28	$47.66	$1.45	$51.79	$1.50
Above 70	90	$42.62	$1.50	$51.93	$1.56	$76.73	$1.95	$81.76	$1.95
Above 90	120	$72.69	$2.60	$83.13	$2.60	$115.69	$2.60	$120.71	$2.60
Above 120		$150.62	$4.09	$161.07	$4.09	$193.62	$4.09	$198.65	$4.09

Table 2-1: Water costs for users in Valle de Mexico (Administración Pública de la Ciudad de México, 2016).

ENVIRONMENTAL ISSUES

Delgado (2015) argues that measuring Green House Gas (GHG) emissions provides a useful metric to understand the complexity and the different implications that water supply and demand have in this metropolitan area because of its connection with energy consumption, as discussed previously. As seen in Figure 2-2, using water inflows alone from 2013, Mexico City and its metropolitan area generated up to 1,162,000 tonnes of Carbon Dioxide equivalent (CO_2eq). CO_2eq is the concentration of a certain GHG in terms of Carbon Dioxide in the atmosphere and it's helpful because it helps normalize the effects. The total metropolitan emissions of methane in terms of CO2e emissions from wastewater outflows have been estimated at approximately 1.5 million tonnes of CO_2eq. Energy consumption for heating water in the metropolitan area is one of the most important components in the end-user emissions as it represents 46% of the total amount of energy consumed by the residential sector. Taking into consideration the total population in the metropolitan area, emissions for heating water generate ~2.2 million tonnes of CO_2eq. In addition, because tap water quality is quite variable an in some areas of the city is not fully potable, part of the population uses bottled water creating another source of emissions related to the manufacture, packaging, distribution and consumption of these water bottles for an estimated total of 1,262,000 tonnes of CO_2eq. As a total, the GHG emissions related to the metropolitan water supply reaches nearly 5.5 million tonnes of CO_2eq per year, making it almost 10% of the total year GHG emissions of the whole country (Delgado, 2015).

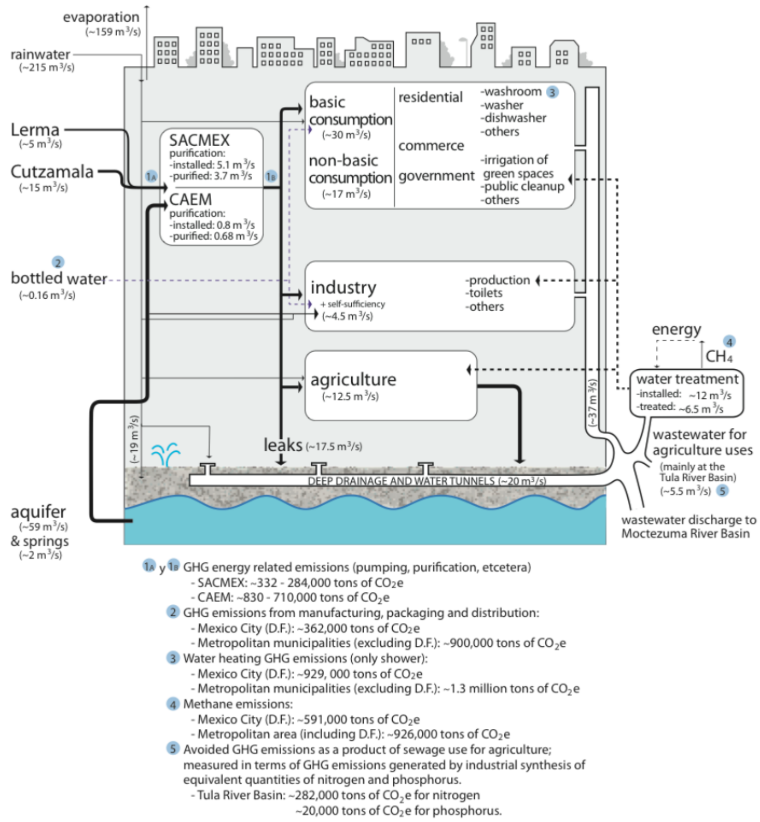

Figure 2-2: Urban water metabolism of the Valle de Mexico (Delgado, 2015).

Besides the significant levels of GHG emissions, the water supply to the Valle de Mexico has created other types of environmental consequences. To mention a few, changes in the use of soil are related to increased water losses due to increased evaporation rates up to 27% have been observed in forested areas, mainly in the mountains. A great number of rivers and lagoons have begun a drying process, which not only threatens the supply to the urban area but all the rural inhabitants from that area. Additionally, extreme contamination due to municipal wastewater discharge, and the large amount of industrial activity without proper code enforcement that has increased on the outskirts of the Valle de Mexico (Escolero, C., et. al., 2011).

TECHNICAL ISSUES

The water supply, as well as its treatment, once used for reuse and subsequent discharge, are necessary actions for the development of population. Assuring adequate supply coverage is subject to the availability of water resources and the capacity for their exploitation, use, and proper disposal or discharge using rational and sustainable approaches; without affecting the environment and guaranteeing at the same time the supply in short, medium and long terms.

About the Valle de Mexico, the high population density has generated a strong demand for water, which has resulted in a severe availability problem exacerbated by the inadequacy of local sources of supply and irresponsible use. At the same time, the demand for potable water implies its purification and after its discharge is used, processes that are complicated given the current infrastructure and the geographical location of the city. Despite the efforts made so far to meet the most basic needs regarding hydraulic services to the Valle de Mexico, it has not been possible to meet these demands at 100%.

The problem of the water system is determined by the increase in the demand for growth of the local population, which determines a low availability of local resources, causing the water supply infrastructure and the sources to be insufficient to satisfy the amount of water available. Reliable water supplies are necessary to sustain the existing population and consequently, water is imported from other neighboring basins resulting in higher costs. In the future, there is the possibility of a gradual reduction of contributions from imported water supply in the event of sociopolitical conflicts. Therefore, to cover the demand, it may be necessary to extract from contaminated areas, such as the eastern zone of Mexico City to bridge any supply gaps. Gaps that are already appearing because reports indicate that there is currently a gap with water supply coverage of only 93.75% of demand in the Valley of Mexico (Cobos, 2017).

The loss of water due to leaks in the network occurs mainly in areas with a distribution network in poor condition due to subsidence and or the age and material of the pipes. CONAGUA (2015) estimates that 40% of the water supplied is lost due to leaks in the distribution system, where 23% is due to leaks in household outlets and the remaining 17% is due to leaks in the distribution network. The flows recovered by leak repair do not improve the service; they only help to maintain it.

Regarding the water treatment and reuse system, the infrastructure is insufficient, due in part to the large distances and the lack of proper infrastructure. To date, it has not been possible to take advantage of economies of scale because the complexity of the drainage network prevents the capture of considerable volumes of wastewater at specific points for its treatment. Tariffs for treated water do not stimulate their use among consumers who may not require the supply of potable water for their use.

The production of wastewater in the Valle de Mexico amounts to 1,255.8 million m^3/yr. The installed capacity for urban water treatment is 8,655 l/s, but only 4,353 l/s are processed. For industrial treatment, the installed capacity is of 1,297 l/s, of which 851 l/s are treated (De la Peña et al., 2013). In general, there is no geographical correspondence between the demand sites and the location of the treatment plants, which limits the use of treated water.

PUBLIC HEALTH ISSUES

Due to the size and population density of the Valle de Mexico, as well as the fact that almost three-quarters of the area depend on the aquifer for its drinking water supply, the protection and conservation of the groundwater quality should be one of the highest priorities. The water waste originated by the domestic, industrial and commercial activity, contain various pathogenic germs and toxic pollutants that, if not handled in an appropriate form, may pose a danger. Until recently, it was assumed that the lacustrine clays that underlie much of the urban area formed an impermeable and protective layer that prevented the penetration of contaminants underground. However, the consolidation of the clay layers have led to the development of surface fractures that can act as conduits for the underground migration of pollutants (National Research Council, 2000; Hernández-Espriú et al., 2014), creating a vulnerability for the aquifer.

The production and management of hazardous wastes is regulated by the General Law of Ecological Equilibrium and Environmental Protection published in 1988. This law imposes restrictions and controls on the producers of hazardous waste; likewise, it requires records and permits the documentation of industrial processes and establishes management practices. Despite the provisions of the law and regulations, currently, the proper management of hazardous waste in the Valle de Mexico has been seriously compromised because lack of enforcement and of the lack of facilities to recycle, treat or remove these residues. In the Basin of Mexico, there are no specific places for waste that have the authorization to receive hazardous materials.

The information on water quality provided by the CONAGUA (2015) indicates that the primary sources of surface water in the Valle de Mexico, the Lerma Cutzamala system, have an acceptable quality in general, with the exception of high levels of fecal coliform in the Cutzamala River. These surface water sources receive treatments by chemical coagulation, filtration, and chlorination. Groundwater is usually treated with chlorination, so all the water is at least disinfected.

In the Valle de Mexico, as in the rest of the country, gastrointestinal infectious diseases are a health problem. Children are especially vulnerable to gastrointestinal types of ailments, which often cause acute diarrhea and, occasionally, death from dehydration.

In 2014, the rate of acute diarrhea in Mexico was 9,700 cases per 100,000 children under 14; 43% of these cases occurred in children under one year (INEGI, 2015).

The National Research Council (2000) states that in addition to the typical problems of developing countries, such as the high frequency of infectious diseases caused by fecal contamination, Mexico faces the particular challenges of industrial societies. Water contamination with toxic chemicals (as well as air, soil and food contamination) is increasing in Mexico. The most hazardous chemicals are nitrates, toxic metals, and other inorganic pollutants, various volatile and semi-volatile organic solvents, agricultural pesticides, herbicides, and radiochemicals. Also, toxic leachates caused by improperly disposed chemical remains, leaks of underground storage of industrial products or energy generators, rainwater contaminated by air pollution, runoff in agricultural areas and waste are potential contributors of mining activity. Some chemicals can cause acute or chronic toxicity. Others may be genotoxic and have carcinogenic, mutagenic or teratogenic effects. Although they are still surpassed as a cause of mortality by communicable diseases, cancers begin to emerge as increasing risks in Mexico and other Latin American countries (National Research Council, 2000).

Chapter 3: The water – energy nexus

Energy and water are resources that are closely linked and are essential for human well-being. The relationship between water and energy is extremely close (Figure 3-1). It is clear that the energy sector cannot fully operate under scenarios of water scarcity and that water supply and water sanitation systems cannot operate without energy. Without water, life is not possible, and energy allows water to be obtained in the quality and quantity necessary both for human consumption and for productive activity. Energy is indispensable for modern life and water is necessary for its production. In this way, the adequate availability of water resources is linked to that of energy resources and vice versa. Pumping, purification, and water treatment require energy and, also, water is necessary for the production, transformation, and consumption of energy. For example, water is fundamental for electricity generation, both in its direct use in hydroelectric plants, as in thermoelectric plants for cooling and emissions control processes.

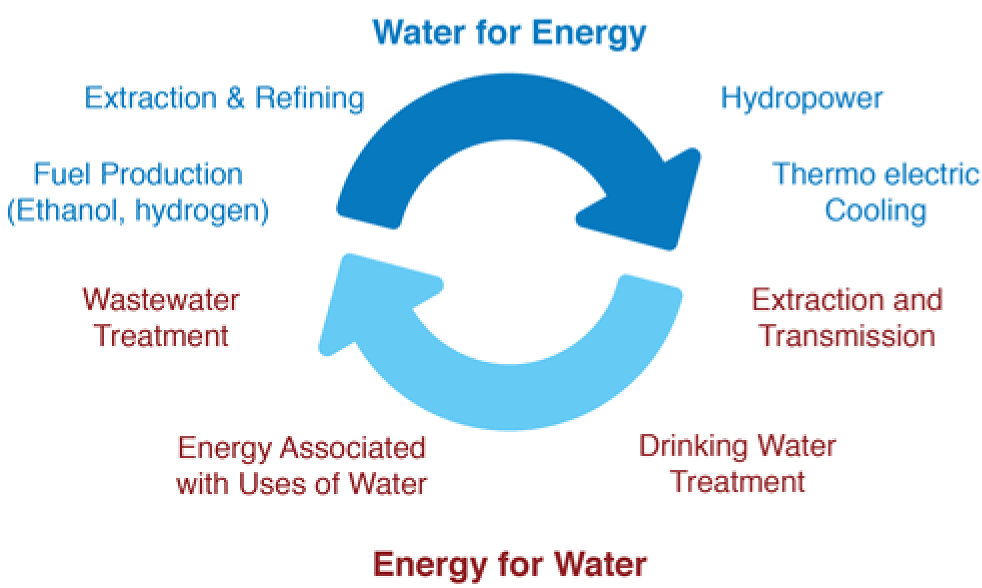

Figure 3-1: Water Energy Nexus (Lehrman, 2012).

Water and energy are necessary for agricultural, industrial and commercial development, and basic services of these resources are required to reduce poverty. The lack of water and energy is one of the key limitations of economic growth and human development. Also, the demand for these resources is growing while facing supply problems, resulting in an increasing need for management that links energy and water. The most obvious correlation is related to the administration of dams for water consumption and electricity generation, but also to the increasingly deeper drilling of wells in aquifers due to the depletion of the water table, which means greater energy consumption for pumping, or with the instability of electrical systems, which can result in intermittent water supply service.

Researchers have noted the lack of accessible information regarding the interconnection between energy and water reflecting limited interest in the water users (Sheinbaum et al., 2015). This gap between the perceived importance of the issue and lack of information to inform decisions becomes relevant as many regions make choices and investments in long-term infrastructure. In practice for example, the availability of water is an issue that does not seem to be at the center of site selection for facilities, such as a new oil refinery or thermoelectric plants. Yet as resources become more strained or scarce, assessing the availability of adequate resources at each prospective site should be a priority in the regional planning and decision making.

WATER NEEDED FOR THE ENERGY SECTOR

Water is used in various activities in the energy sector, ranging from the extraction, refining, and processing of fossil fuels, and electricity generation, to the final consumption. These activities also impact water quality through chemical and thermal pollution or atmospheric emissions that precipitate and can end up in bodies of water. The greatest water consumption occurs in the extraction and processing of fuels. The final energy consumption implies minimum water requirements.

The production of hydrocarbons (oil and natural gas) and its derivatives mainly includes exploration, extraction, transportation, and refining. Exploration is an activity that, in its final stage, includes the drilling of wells to verify the existence of the product. During this activity, as well as in the exploration activity of wells, water is an integral part of the different stages of the process. It is a fundamental ingredient of many drilling muds, it can be injection fluid in mature fields to drive hydrocarbons to wells, it can be pumped to steam wells to liquefy bituminous sands and heavy oil, and it also functions as a fluid fracture to break the clays and allow the free flow of natural gas between the rock (Cohen, 2008). The further problem is that, during the extraction of hydrocarbons, water that was found in the underground formations along with oil and gas is released. The quality of this water varies according to the deposit, but in most cases, it has several pollutants, among which the high degree of salinity stands out (WEF, 2009). This water is usually disposed, either by deep injection into the ground or by its subsequent discharge after treatment to the surface. Both activities have a high cost. The injection must be done in geologically insulated formations, so it does not contaminates underground drinking water sources, and in many cases, it requires prior treatment to avoid clogging of the formation that receives it and damage the injection equipment (Cohen, 2008).

Technologies based on thermoelectric generation, which use steam to move generating turbines, require chillers to condense the steam. The operation and cooling involve a significant amount of water consumption. In Mexico, in 2016, thermoelectric plants, including independent production, generated 254,533 GWh, which represented 80% of the total electric power produced in the country (García, 2017). The oldest thermoelectric plants were built near surface bodies of water. These plants usually operate under open cooling cycles, which means that they take water from the source and discharge water to the same source at a higher temperature, which produces a wasteful consumption of the resource and thermal pollution within the water bodies. In 1988, the government issued the first Mexican standard that established the maximum permissible waste limits, and the procedure for the determination of pollutants in wastewater discharges in water bodies from conventional thermoelectric plants. This legislation was updated in 1993 and incorporated into the NOM-001 standard in 1996, which establishes the maximum permissible limits of pollutants from discharge to national waters and set a maximum discharge temperature (Sheinbaum Pardo et al., 2015). Most modern thermoelectric plants use closed systems, where the water is cooled through a cooling tower or pond. These systems discharge less than 5% as compared with open-cycle plants since most of the water is lost through evaporation (DOE, 2006).

The fall of water is the source of kinetic energy for the generation of electricity in hydroelectric power plants. Once it passes through the turbines, the water is returned to the flow of the river. For this reason, the water concession to the hydroelectric power stations by the water agency, CONAGUA is not categorized as consumptive. Hydroelectric plants evaporate more water in reservoirs than evaporation rates in natural river systems resulting in net consumption of water (Sheinbaum Pardo et al., 2015). The result is that permitting mechanisms inadequately account for the water budget of hydroelectric facilities and undervalue water resources. On the other hand, the storage of water in the dams, necessary for electricity generation, provide other beneficial uses and services, such as improved flood control for communities which may offset the incomplete accounting of the water budget.

Every point of exchange between energy and water systems presents uncertainty and challenges to budgeting and accounting approaches. The amount of water used to operate the technology based on renewable sources of energy is also variable. In the case of electricity generation, the use of water for wind turbines or photovoltaic panels is practically negligible. However, in the case of geothermal energy, water is essential for the operation and cooling of the turbines, as well as in solar concentrator plants. It is estimated that the average consumption is 5.3 m^3 per MWh in the case of geothermal energy, and 2.8 to 3.5 m^3 per MWh in the case of solar concentrators (WEF, 2009). In the case of bioenergy supported by the cultivation of grains, the consumption of water is very significant, but it is obvious that it depends on the type of crop and how and where it is grown and, above all, whether it uses irrigation. It is estimated that water consumption can go from 9 m^3/GJ in the case of corn, to 250 m^3/GJ in the case of soybean (WEF, 2009). The production of ethanol is based on a fermentation process that requires greater water consumption than biodiesel.

ENERGY NEEDED FOR THE WATER SUPPLY

This section describes the consumption of energy for the different uses of water, as reported by CONAGUA in Figure 3-2. In this way, according to the information available, the estimate for agricultural irrigation, public supply, and some considerations on energy for water consumption in the self-supplied and thermoelectric industry.

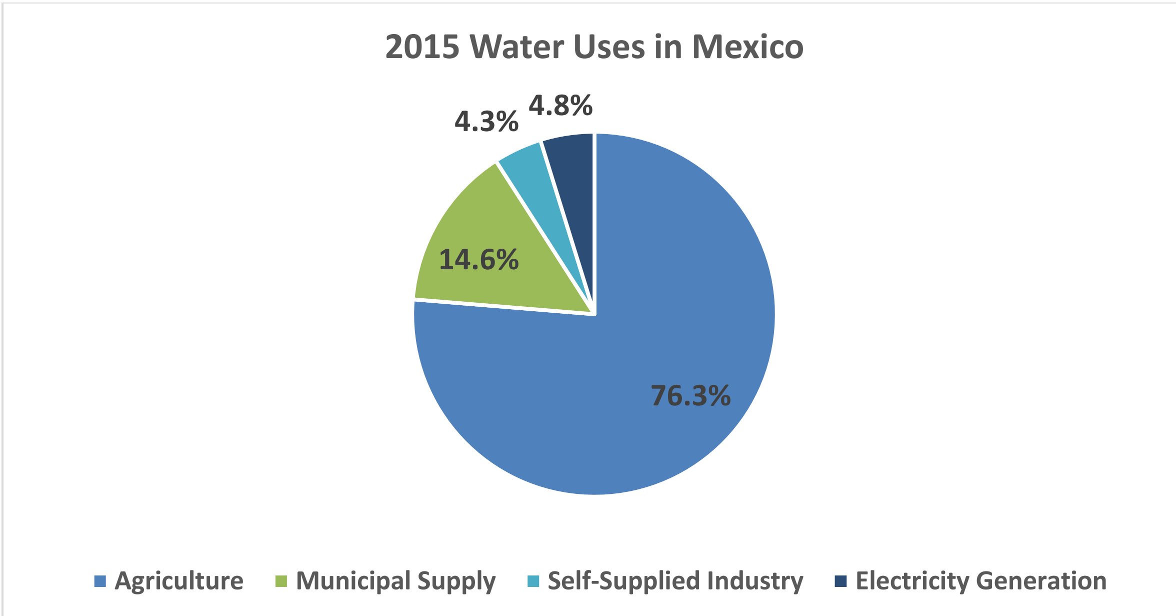

Figure 3-2: Water uses in Mexico in 2015 (CONAGUA,2016).

Agricultural activities are the main water use in Mexico, accounting for 76.3% of the water extracted in 2015 (CONAGUA, 2016). Of this, two-thirds was sourced from surface water and the rest from groundwater. In general, irrigation methods can be classified into surface, pressurized (spray, micro spray, and drip) and underground irrigation, in which water is supplied through the use of electric pumps, gasoline pumps, use of channels or the combination of any of the three. In the case of surface irrigation, water is distributed by gravity through furrows and is characterized by its low efficiency, between 40 and 60%, due to its high evaporation index, although it has the advantage of incurring lower energy costs (Fernández, 2005). Spray irrigation, which simulates the effect of rain, requires water under pressure and has an efficiency of 85% on average. Underground irrigation is carried out with permeable pipes buried at a shallow depth to moisten the soil, but poor control of the humidifiers and their high cost limit their use. Additionally, a portion of water consumption that can be attributed to agriculture is from of the energy required for irrigation supplied by gasoline and diesel pumps, yet there is inadequate information to estimate increases in water consumption due to use of these fuels for agriculture. To a lesser extent, water pumping schemes have also been developed for irrigation through renewable sources with promotion by government programs such as the Fideicomiso de Riesgo Compartido (FIRCO) (Sheinbaum Pardo et al., 2015).

The public water supply network is a system of interwoven engineering works that allow water to be carried to residential homes, as well as to the various industries and services connected to these networks. These systems require energy for the pumping of water in the extraction of wells, transportation, distribution and lift to water tanks, as well as for pumping of drainage systems and the energy necessary for the purification of water and sewage treatment. In many cases before supplying users it is essential to treat the water to make it potable. Treatment procedures range from simple disinfection to desalination, are applied according to the origin of the water creating yet another complex link in the overall water network. In the case, for example, of the Cutzamala system, the water is transported a distance of over 160 km requiring pumping lift over more than 1,100 m of relief. The corresponding energy consumption is estimated at 2.85 kWh per cubic meter (Breceda, 2004). Across the country, in 2012, 137 Mm^3 of water were made safe in the Valley of Mexico (De la Peña et al., 2013). According to the WEF (2009), 26 kWh are required to purify one million liters of water, therefore a reasonable estimate of 3.56 GWh for consumption in Mexico is needed to purify adequate resources for water supply.

The water quality required for industrial use is usually lower than that required for domestic use, except for specific industries such as the food industry, where purified water is essential almost 80% of industry water consumption is carried out by only six industrial subgroups: sugar, chemicals, oil, pulp and paper, textiles and beverages. Of the total industrial consumption, 50% is used for cooling, 35% in processes, 5% in boilers, and 10%

for services (Castelan, 2000). Water is used by industry in different ways: to clean, heat, cool, generate steam, transport dissolved substances or particles, as a raw material, as a solvent, among others. Treatment plants consume energy, and the energy consumption increases according to the degree of treatment, therefore, of the 29.9 m^3/s of wastewater generated in the industries, 35.6% receives primary treatment, 50.5 % receives secondary treatment. 2.1% receive tertiary treatment and the remaining 11.8% do not have information regarding their treatment (Sheinbaum Pardo et al., 2015).

RISKS AND OPPORTUNITIES OF THE WATER – ENERGY NEXUS

Even though the consumption of electric energy for water uses represents about 7% of the total electric consumption; and that the water consumed by the energy sector represents 6% of national water consumption, its relation is substantive for the development of the country (Sheinbaum Pardo et al., 2015). The energy sector cannot operate without water or water shortages, and the supply of drinking water and the operation of drainage cannot operate without energy. At least five topics represent possible risks in this regard; 1) climate change, 2) the balance in the multiple uses of water, 3) the efficient use and treatment of water associated with energy uses, 4) efficient use of energy in the provision of water, and 5) the management of water in hydroelectric plants.

The impacts of climate change on the global water balance are documented to the highest degree (IPCC, 2007, Sheinbaum, 2008). These can cause problems with scarcity due to drought or abundance associated with floods, in addition to the impacts of events such as hurricanes. The vulnerability of the energy sector to these events must be studied and treated, as in the planning of the sector as in the supply of current plants. Given the high consumption of water in thermoelectric plants in service to other industries, the issue of water supply for power generation and the potential impacts of climate change must be recognized and addressed.

In response to the associated risks, there are several approaches that can be considered such as reducing demand via competition among users, encouraging reduced demand via water use efficiency gains, and coordinate administration of the resource to improve allocations. Demand reduction may be achieved by amplifying competition across economic sectors, currently irrigation accounts for the greatest consumption of the resource and Ag users are inefficient. It's possible that improving the application of tariffs could encourage more economic behavior amongst agricultural water users. There is an enormous potential for decreasing the consumption of water for irrigation in Mexico via comprehensive programs that stratify the characteristics of agricultural producers for example, and public support should be given. To suppose that it is only a problem of adjustment of water and electricity tariffs is to excessively minimize the universe of the problems of the Mexican irrigation farmers.

The energy sector has opportunities for increasing efficiency and reducing demand, particularly in the water installations related to refining, petrochemical and thermoelectric plants. The two biggest state corporations are PEMEX (Petróleos Mexicanos) and CFE (Comisión Federal de Electricidad). PEMEX is the largest petroleum company and it is owned by the state. CFE is the largest electricity supplier in Mexico. While major actors in the energy and petrochemical sector, such as Pemex and the CFE have made efforts in this regard, they still face issues of low water efficiency and high water demand. The agricultural sector has vast opportunities for decreasing water consumption by through reductions in energy-side demand by reducing energy demand through the use of renewable sources of energy for water pumping, The link between water and energy in hydroelectric plants is obvious. However, more planning is required between water and energy uses, as well as the risks associated with drought and floods. Particular attention requires the management of the national electricity system and competition between independent producers and the hydroelectric plants of the Federal Electricity Commission (CFE).

Finally, it is necessary that CONAGUA, CFE, the Energy Regulatory Commission, SENER and PEMEX establish coordination mechanisms for the coordinated administration of resources. To begin with, a nation-wide information system is required to make it possible to know the water consumptions for the national energy industry, as well as energy consumption for the various water uses. There are essential efforts needed to decrease the use of fresh water in the energy sector. Such is the case of the use of seawater and the increase in water recycling within Pemex and the treatment of municipal sewage for use in CFE thermoelectric plants. However, more information is required to better estimate the potential for saving fresh water in these and other related activities. In the field of electricity consumption for pumping, purification, and treatment, more information is also required to know the potential for savings and efficient use.

Chapter 4: Methodology

This chapter provides the methodology and guidelines used in this research. It includes the process used in the open-ended interviews and surveys with the Mexican residents in the Valle de México. The research methodology was processed and approved by the Office of Research Support of the University of Texas in Austin and obtained the "Exempt" status from the IRB review. IRB number 2017-04-0072 (Appendix A).

RESEARCH PURPOSE, DESIGN AND PROCEDURES

Using mixed- methods to integrate physical and social perspectives, this research evaluated *"How people perceive vulnerability in the water supply system and how do they frame possible consequences and/or solutions for managing the multi-attribute tradeoffs needed to define a management scenario?"* The research aimed to include interviews with representatives from the three principal user sectors: municipal, industrial, and agriculture. Using an open-ended interview and survey design participants were asked questions directed toward understanding the perceived impact of the actual water supply process and how uncertainty in water supply can impact the local economy as well as other issues. In general, a survey can be defined as a technique that uses a set of standardized research procedures through which a series of data is collected and analyzed from a sample of cases representative of a larger population or universe, which is to be explored, described, predict and/or explain a series of characteristics (Casas Anguita et al., 2003).

Data was collected using one of two survey versions depending what worked best for the setting and/or accessibility to stakeholders: open-ended conducted oral interviews or hard-copy surveys. The hard-copy was used when a group of participants were able to participate in the surveys, so each one of them could answer the questions without interference from the rest. The oral version was used when there was only one participant at a time and he or she had the time to sit down for a face-to-face talk. Most of the time, the verbal version was used. Each interaction with the participant lasted between 10 minutes and 1 hour depending on the length of the participant responses to questions and whether it is an open-ended conversation or a hard-copy survey. Preliminary conversations, interviews, and surveys were proposed to clarify some perspectives of stakeholder groups about the water resource supply management decisions. These interviews and surveys provided an initial picture of the conceptual problems formulations, perceptions, values, challenges, and key considerations that different groups identify as important. Results from interviews and surveys were captured by the researcher by taking either handwritten notes and/or capturing comments using word processing tools on a portable laptop computer.

STUDY LOCATION, TIMELINE, MEASURES

The interviews, conversations, and surveys were completed in Mexico, specifically in the Valle de Mexico (Figure 4-1). The Valle de Mexico metropolitan area is composed of 76 municipalities that are part of Mexico City, State of Mexico, and State of Hidalgo. This study includes Mexico City and 7 suburban municipalities. All the surveys and interviews took place in private rooms to assure that all the information provided was private. This research required a single interviewer to perform the face-to-face interviews and hard-copy surveys. All data collection was completed over one month from July 15th through August 18th of 2017. The interviews and the hard-copy surveys had the same questions that are included in Appendix B of this thesis.

Figure 4-1: Location of the Valle de Mexico within Mexico (CONAGUA, 2016)

PARTICIPANTS

The subject populations include Mexican residents from the Valle de Mexico of either of the municipal, industrial, or agricultural sector. A total of 192 subjects participated and all subject were over the age of 18, healthy, and able to give voluntary informed consent. Vulnerability to coercion or undue influence is not applicable to participants in this study. Participants were selected for inclusion or exclusion using the following criteria:

- Users from the water supply system,
- Willing to participate and give verbal consent,
- Available at the time of the study,
- Residents from the Valle de Mexico

There was no direct financial benefit for participating in this research. A potential benefit is that the provided information by open-ended interviews and hard-copy surveys with participants may lead to improving the understanding of how science-based data can inform community response and deliberation around topics of concrete for multi-party dialogue in water supply issues. Additionally, research outcomes have the potential to identify a feasible space for negotiation in which stakeholders can find solutions to the water supply issue. These actions would be an indirect result of conducting the research and could have an influence or impact on the lives of those participating and living in the Valle de Mexico.

Risk during the interview and survey process is no more than that found in daily life. The primary risk to participants was due to social perception as it relates to an individual's position of a point of view on the water supply issue. To minimize risks specific to this research project, verbal consent was requested. The researcher went door-to-door to meet residents in the different municipalities to reach for participants that were willing to participate in the research

PRIVACY AND CONFIDENTIALITY

Data was captured as handwritten notes or on a portable laptop computer collected at the time of the interviews.

a) Data was collected using notes from the interviews that were conducted or the hard-copy surveys that were answered by the participants.
b) All the notes collected during the conversations and the responded surveys were on the researcher's possession at all times or in the locked cabinet in the researcher's house during the data collection process. Same applied with

the data obtained when the researcher returned to Austin to continue with the data analysis.

c) The data obtained from the open-ended interviews or hard-copy surveys were kept until the research was finished.
d) All the interviews, conversations and surveys were anonymous and data was not shared with other researchers that were not related to this study.

INTERNATIONAL RESEARCH

This research was conducted in Mexico, specifically in the Valle de Mexico that includes Mexico City, the State of Mexico and the State of Hidalgo. As a Mexican resident, I was aware of all the local customs, cultural context, laws, and regulations in the Valle de Mexico. Interviews and surveys were completed in Spanish, which is my native language; therefore, language was not expected to be a barrier to communication. I have conducted, in my previous jobs, interviews for marketing research. I did not consider that I was going to have any problems for doing this research in Mexico because of my previous experience. There was no need for this research to require local ethics committee review and approval and/or permission by any local, provincial or national government entity. In case there was any problem while doing my research in Mexico, I would communicate with my supervisor Dr. Pierce and the University of Texas through phone or email. No problem arose while being in Mexico conducting these surveys. Dr. Pierce and I were in constant communication by mail or phone while I was in Mexico conducting the research. Any progress or problem I went through during all the research was communicated to Dr. Pierce in an immediate way for her to give me feedback.

In order to conduct the surveys and interviews in Mexico, the International Oversight Committee (IOC) approved my request to visit Mexico that is part of the Restricted Regions Travel List (Appendix C).

DATA ANALYSIS

The data collected from the surveys and interviews were analyzed using a spreadsheet tool. Because most of the questions were open-ended, responses were grouped for analysis (Appendix D). After the spreadsheet was created, statistical formulas were used to analyze the data together with an artificial intelligence program from Watson Analytics (IBM). Watson Analytics is a computational tool that allows a user to refine, explore, and analyze big data sets to assess the key driving factors that influence the results. The Watson Analytics tool is useful for evaluating data in a clear way to explain to other stakeholders with the main goal of completing complex data analysis to facilitate a decision-making process. Although the primary use of Watson Analytics is not to analyze surveys, this research adapted the application to analyze the database and assess patterns within the different responses, providing valuable insight about perceptions of the research participants' responses regarding the water crisis.

Watson Analytics works with the upload of a database from Microsoft Excel. Once you upload the data you want to work with, the program lets you go into one of four categories: Explore, Predict, Assemble, and Refine. The differentiator of this program is that it will not show you your database, but instead, it will show you a preview of an analysis that can be done with the data that you already have. Although the program shows some of the most substantial findings that match your data, with the help of the easy-to-use interface, you can introduce new questions that Watson Analytics will answer by matching the data you are asking for. Then, when you finished analyzing the data, you can predict future conditions from the results you found. Finally, you can assemble different charts to communicate in a more efficient way your findings and the decisions you took based on them. The software works by doing different comparisons, correlations, and contrasts and showing you figures and graphs that will help you decide in a more natural and informed manner.

Chapter 5: Results

The purpose of this research was to determine the water users' perceptions regarding the water supply system in the Valle de Mexico and determine which characteristics may influence their perceptions about this issue, if any. This chapter presents in-depth description of the results obtained through interviews and surveys (Appendix D).

DEMOGRAPHICS

A total of 192 residents from the Valle de Mexico responded to either the survey or the interview. Although this is a small sample for a population of 23 million inhabitants, this study's purpose was to provide an initial assessment that highlights the inputs and perceptions of the water supply system users. Initial results from analysis indicates that this study provides a good initial starting point for research, with opportunities to extend the research with the goal of collecting a larger set of participant responses from a population that is representative of the full Valle de Mexico basin. For example, one approach would be to take into account the actual population of each municipality and normalize the number of participants according to the demographic distribution of each sub region in the study.

Categorization of the 192 participants reveals the following demographics for respondents to this study: 66% female, 34% male, 88% from Mexico City, 12% from the State of Mexico, 96% municipal users, 3% industrial users, and 1% agriculture users. Figure 5-1 shows a map showing the locations of the participants within the Valle de Mexico. There were participants for each and every one of the 16 municipalities that form part of Mexico City. From the State of Mexico, as discussed in the previous paragraph, this study only focused on 7 municipalities that are the closest and most population-dense in the Valle de Mexico. The three economic sectors that the Valle de Mexico has (municipal, industrial, and agriculture) were taken into consideration in the percentages that the CONAGUA reports the use of water (CONAGUA, 2016).

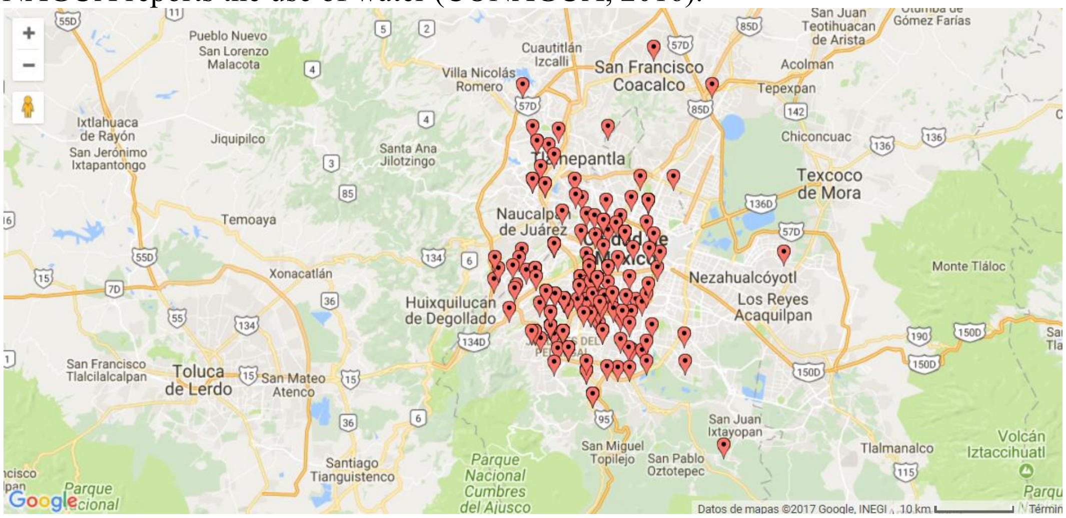

Figure 5-1: Participants' locations.

While all the participants were 18 years or older at the time the surveys and interviews were conducted, most of the participants, 76%, were below 55 years old. The following figure (Figure 5-2) shows the distribution of age range of the 192 participants.

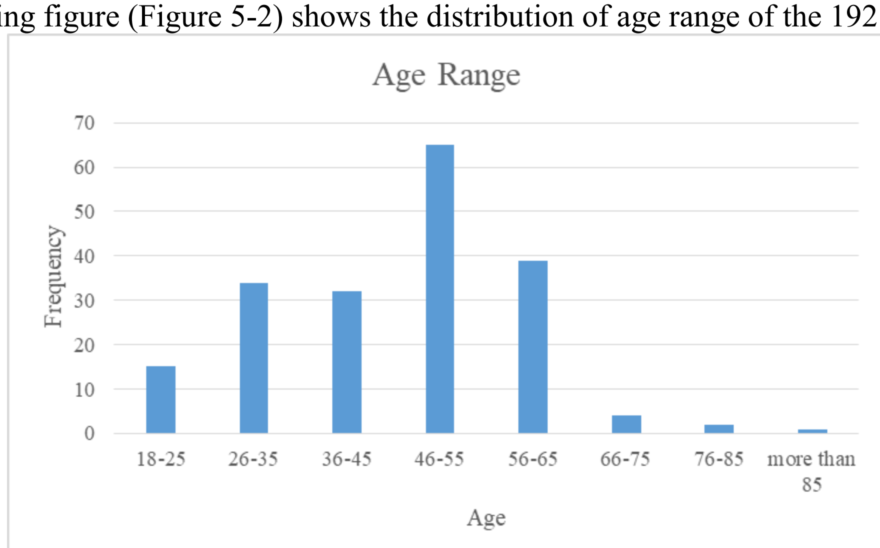

Figure 5-2: Age Range of the respondents.

DRINKING WATER CONSUMPTION

Figure 5-3 shows the bimonthly water expenditure in Mexican Pesos. As the figure shows, residents spend most frequently less than \$500 MXN but 12 participants pay more than \$3000 MXN. The costs of drinking water ranged across a significant span of values with residential users reporting that they pay less than \$100 MXN while others report paying more than \$500 MXN every week. 86 of the respondents, 47%, pay less than \$100 MXN per week on drinking water. Most of the residential users, 89% pay less than \$300 MXN per week on drinking water for themselves and their families (Figure 5-4). In the case of agriculture and industrial users, 43% of them pay more than \$500 MXN, while the remaining respondents, 57%, pay between \$100 and \$200 MXN.

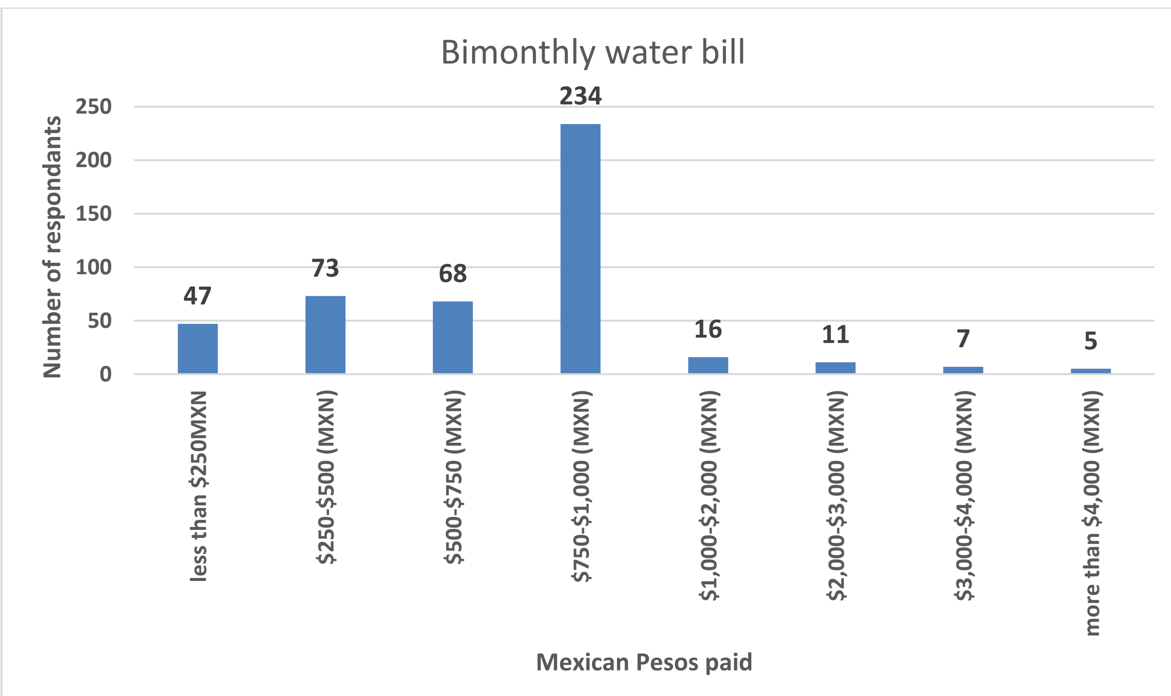

Figure 5-3: Bimonthly water expenditure per household

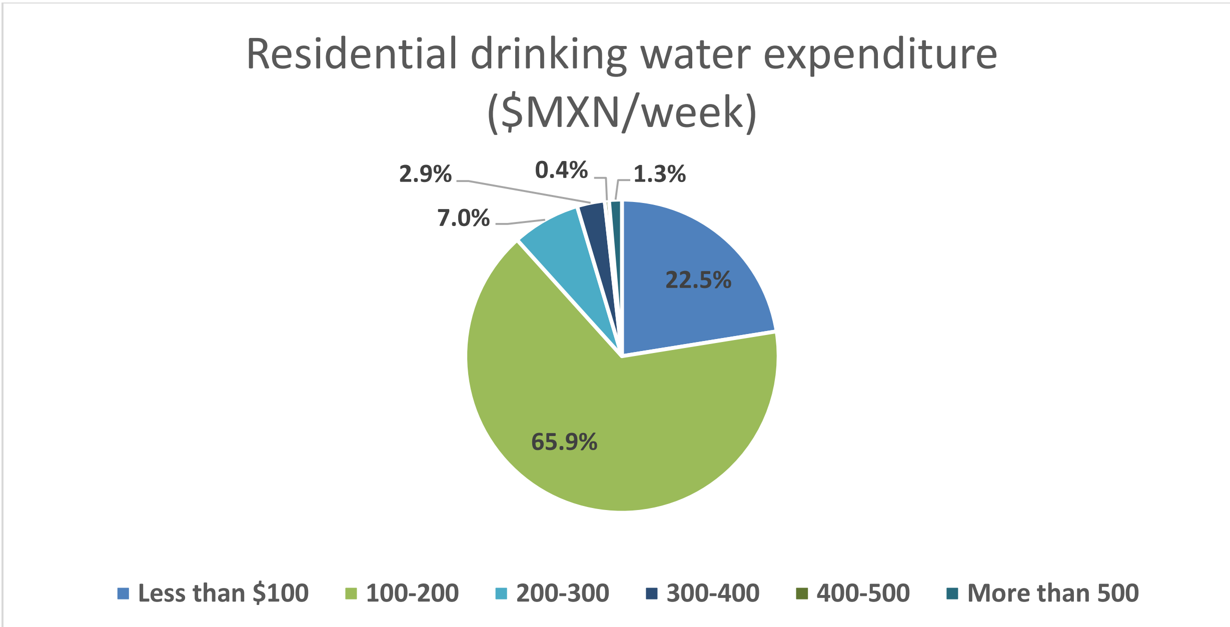

Figure 5-4: Residential drinking water expenditure per week

The daily consumption of the water users in the Valle de Mexico ranges from “less than 500 ml” to “more than 2 l.” per day (Figure 5-5). The most frequently water consumption between the inhabitants of the Valle de Mexico is 1 to 1.5 lt. per day.

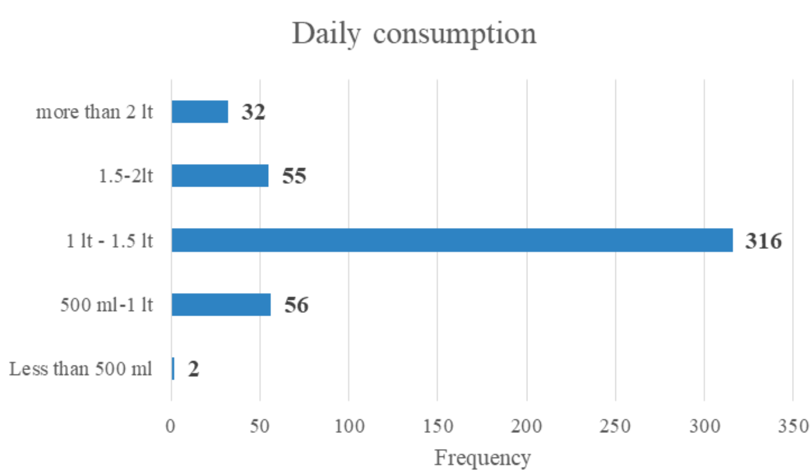

Figure 5-5: Water daily consumption in Valle de Mexico

Tap water in Mexico is not of drinking quality, and the Valle de Mexico is no exception. Because of this issue, the residents need to buy additional bottled water or treat their water from the tap using additional processes, like boiling and/or filtering, in order to obtain drinking water for their household. 46% of the inhabitants use 42 lt. jugs of water that they buy periodically. 33% of the residents use water filter in their homes, while 15% uses additionally individual water bottles. Other forms of having potable water are boiling water, disinfecting water with iodine drops, and even treating water with activated carbon.

WATER SHORTAGES

When asking the participants whether or not they suffer from water supply shortages, 47% of them answered that they did. For the 91 users who answered that they suffered water shortages, 4 follow-up questions were used by the researcher in order to learn more about respondents' actions and perceptions when they suffer from these shortages. Figure 5-6 shows the frequency in which these water shortages happened. As it can be seen in Figure 5-6, 50% of the inhabitants suffer from shortages a few times per year. Surprisingly, almost 30% of the participants that have water shortages, reported experiencing the shortages at least once per week.

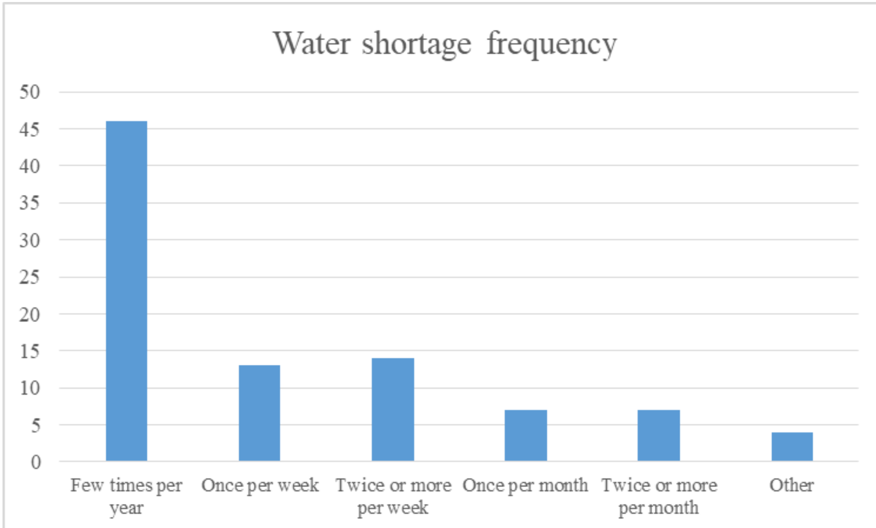

Figure 5-6: Water shortage frequency.

Respondents were asked about their responses during a water shortage event and, specifically, what they do during these water shortages. Although there were plenty of answers, the four most frequent responses indicate that water supply system users contract services from a water tanker company. If the government issued warnings about future water shortages, the people is willing to save water in buckets beforehand and use less water during the shortage period. When asked "to whom they go when they have water shortages," the number one response with 36% indicated "no one." Another top response was "water companies to get water tankers." People were willing to go to friends or family for water before asking municipal, state or federal agencies. Finally, when they were asked "who should be involved," the most frequent answer was the "Federal Government" followed by "everyone" and "State Water Agencies."

User Perceptions

Most of the participants think that the water supply issue is important. 63% of the residents answered that this problem has an importance of 10 (the highest answer available) with a mean of 9.2. When asked "their water supply system description" the most frequent responses were quite the opposite; some of the participants described the water supply system as "acceptable," "good," or "adequate," while others said, "unacceptable," "bad," or "insufficient." Most of the residents think that the industry is the one sector that creates the most demand of water in the Valle de Mexico. When they were asked "how important is the water supply issue in comparison with other issues of the region," 49% answered that it was the "Most important" (Figure 5-7).

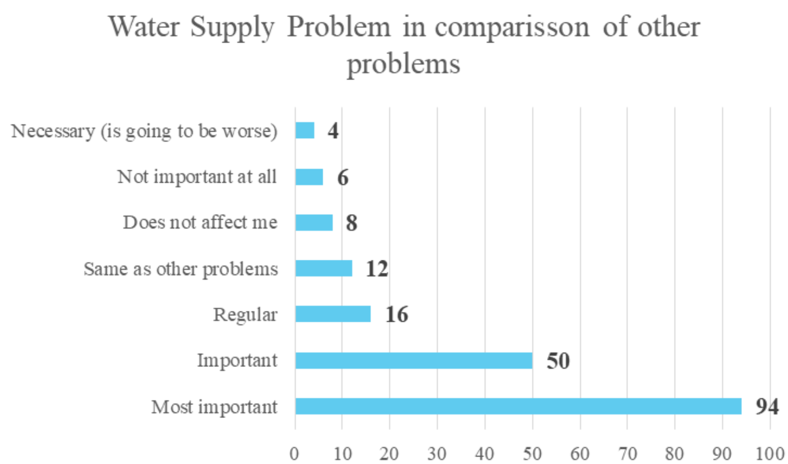

Figure 5-7: Water supply issue in comparison with other problems.

Responses shown in Figure 5-7 show that other problems were also mentioned. Of the total, 26 people mentioned that "Security" was as important as or even more important than the water supply issue. Corruption, urban design, economy, and population growth were also mentioned, but each of them had less than 5 responses each.

The participants were encouraged to mention solutions, what could they do to help solve this problem, and to identify what they perceive to be the most important topic within the water supply issue. Figure 5-8 shows the responses for “Most important topic within the water supply issue.” “Infrastructure” is the top one answer, while “create awareness” and “drinkable tap water” were less frequent but still had a lot of responses.

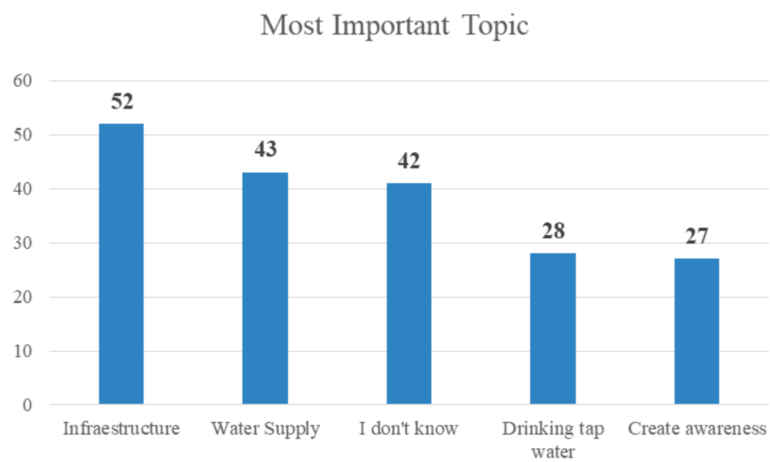

Figure 5-8: Most important topic within the water supply issue.

Participants provided responses for many possible solutions. The most common responses included “create or give maintenance to the infrastructure,” “harvest water rain,” “educate,” and “repair leaks.” Interestingly enough, when participants were then asked “what could they do to help solve the water supply issue” between the answers was “nothing.” Other answers for this question were “use less water,” “reuse water,” and “notify leaks to the authorities.”

Chapter 6: Analysis

The interviews and surveys illustrate some of the current perceptions of the residents in the Valle de Mexico in relation to their household water supply. Understanding these perceptions may help decision makers identify possible solutions that take into account the ideas, preferences, and concerns of the population. First, it is important to make a general analysis of the situation; explain the different water shortages that exist and what the actual water supply in the Valle de Mexico is. Then, the general data from the surveys and interviews is analyzed and the results are exposed. Finally, having the different demographics help analyze the data to see common behaviors in the different sectors that compose the population.

General Situation Analysis

The World Health Organization (WHO) states that a total of 20 lt. per capita per day should be assured to take care of the basic hygiene needs and the basic food hygiene. The World Economic Forum (WEF, 2017) states that Mexico is the fifth country in water consumption per capita with 366 lt. per day. This value is consistent with the 83 m^3/s that is supplied daily to the Valle de Mexico. Considering that 23.5 million inhabitants (INEGI 2015) live in this area, this 83 m^3/s are equal to 305 lt. per day. However, there are a lot of claims throughout the Valle de Mexico that state that they suffer from water shortages. With an average supply of 305 l/day, there should not be any kind of water shortage. CONAGUA states that around 40% of the water that is supplied to this area is lost due to leaks. Of that 40%, 23% of the leaks are found in the homes and the remaining 17% are in the distribution net (Ramos Guzmán, 2015).

Assuming the 40% of the water is indeed lost due to all types of leaks, this means that those 305 lt. per day per resident becomes 183 l is also important to mention, that the water is not supplied to the different municipalities in a continuous way, but rather in a batch mode. This could be the reason why the population perceives that there are water shortage conditions. Because of this discrepancy, it is important to define two forms of water shortage: water shortage that is not mitigated by management, and the water shortage that is perceived and exacerbated by behavioral or cultural practices.

The water shortage that is not mitigated by management, is 40% water that is lost from the source to point of delivery where the users consume it. This water shortage could be solved if the water agencies in charge of the water distribution maintain or renovate the infrastructure and actively repair all the leaks. For this solution, requires involvement and cooperation from the citizens because some of the leaks occur within the residents' homes, and they may be aware or not about this issue.

The water shortage that is perceived and exacerbated by behavioral or cultural norms, is the water that is perceived as scarce because of the poor water usage practices. In fact, these supply shortages, if compared to an actual situation with extreme water scarcity, may not qualify as an authentic shortage because the supply is present but the distribution and system capacity is not being used efficiently resulting in intermittent supply despite the fact that the overall water provisioned to the system is sufficient to meet demand. As the WEF (2017) shows, Mexico has a high consumption of water when compared to the average consumption around the world. The residents consume much more water than the 20 lt. per day that the WHO states as a basic need. In this case, taking into account that a lot of water is lost due to the infrastructure, more water may be lost because of the users' behavior. There are a few reasons for the wasteful use of water: lack of education, lack of awareness about the importance of using the water in a responsible way, contamination, and selfishness, among others. As mentioned before, the water is supplied to the different municipalities in batch mode instead of being supplied in a continuous form, if the residents are using and wasting more water than the quantity they should responsible use, then they are creating the shortages by their own actions.

GENERAL SURVEY AND INTERVIEW ANALYSIS

The general data analysis includes the key inputs presented in the previous chapter and the analysis presented below were generated using machine learning techniques from IBM Watson Analytics. Figure 6-1 shows the relationship between the answer “important in comparison with other problems of the area” and the bimonthly water expenditure. As the figure shows, most of the participants that pay less than 250 MXN believe that the water supply issue is “very important/primordial”.

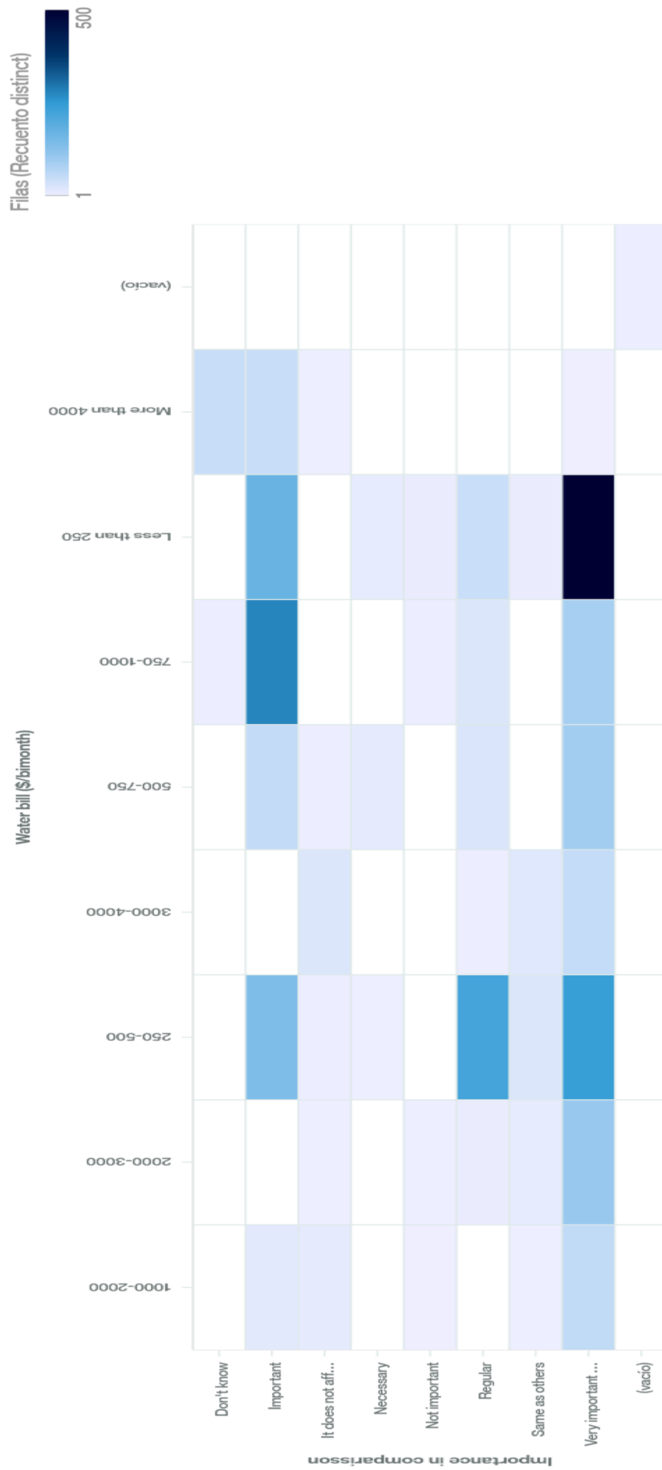

Figure 6-1: Importance in comparison with other problems in the area vs. water expenditure.

Figure 6-2 shows the perception of the residents about who creates the demand for water in the Valle de Mexico. Industry is what the population think that is the highest driver of demand of water in the area, but it is important to mention, that CONAGUA states that only 3% of the water is for industrial purposes (CONAGUA, 2016). The other two important water users in the participant's answers are population and municipal use. It is important to mention the difference between these two: population is the water that the residents use in their own houses, and municipal is the water use in the common areas of the municipality.

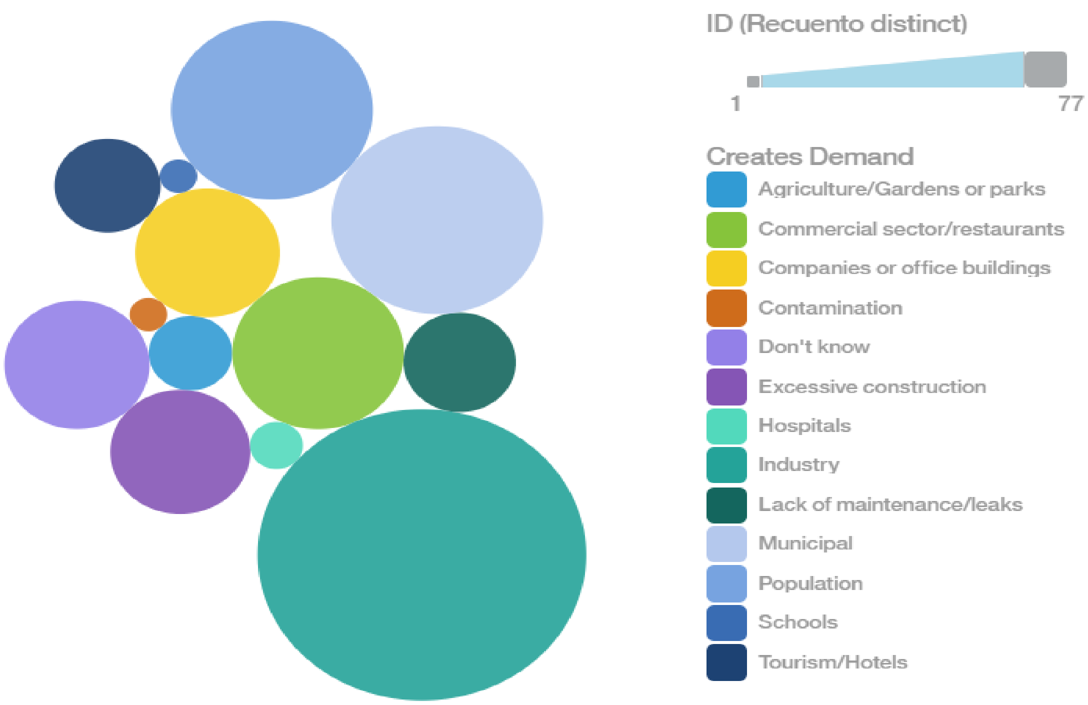

Figure 6-2: Who creates the water demand?

The most important function that Watson Analytics has is that it calculates what generates some specific graphs, based on the connections it has to other responses inside the file. It is interesting to show, that the importance of the water supply issue for the participants has a driven force of 63% if it is compared to the age range. Figure 6-3 shows what generates the participant's importance in this topic. The least connected answer is both "solutions" and "who should be involved in solving this problem" with a 28% of incidence over the overall importance.

Figure 6-3: What drives the perception of importance from the users?

GENDER ANALYSIS

The resident's perceptions may vary by gender so it is important to analyze the data having this in mind. 66% of the participants were females, 89% of them live in Mexico City and the remaining 11% are from the State of Mexico. The remaining 34% of the participants are male, 86% of them live in Mexico City and the rest in the State of Mexico. As Figure 6-4 shows, the behavior of water consumption is pretty similar in both, males and females. Filters, individual water bottles and 42 liter jugs are the most common way in which the residents consume water. It is also interesting to notice that only females mentioned that they use 10-lt water bottles, or that they disinfect the water either with drops or activated charcoal filters.

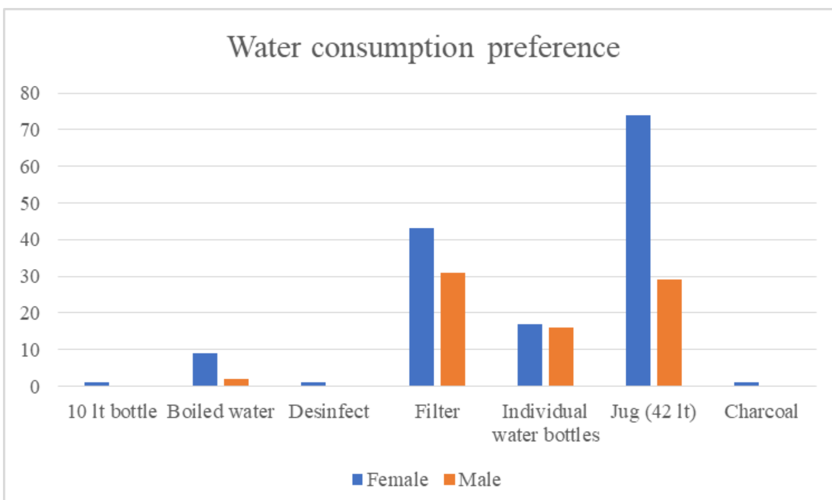

Figure 6-4: Water consumption preference in males and females

Comparing the water consumption between females and males (Figure 6-5), it shows that the general behavior is similar, because both genders mostly consume between 1 and 1.5 liters of water per day. But in a more in depth analysis, it can be seen that most of the females (89%) consume between 500 ml and 2 lt.; while in the case of the males, 80% of them consume from 1 lt. to more than 2 lt. per day.

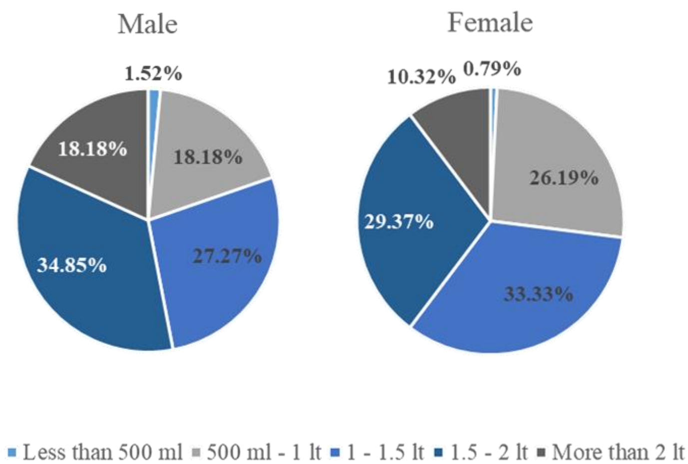

Figure 6-5: Water consumption behavior in male and females.

When analyzing by gender, most of the responses are similar between males and females, however, this does not happen when the participants are asked to described the water supply system in the Valle de Mexico. Males describe the system in the first place as “acceptable/adequate/good” followed by “cheap/not expensive” and “depends on the economic status”. In the case of the females, the most used description is “Bad/Deficient/Inadequate”, followed by “regular/sufficient” and “expensive”. Both genders hierarchy description is completely opposite the one from the other. While men think it is a good supply system, women believe it is a terrible one. Another interesting thing is that men think the water supply system is “cheap” while women think it is “expensive”. This may be because sometimes the ones that have to administer the household budget are the women and they see how each of the different needs of the house play a more or less important role in the whole budget. In this cases, men gives the budget but do not see how was divided.

Both, females and males, have a similar average when they evaluated the importance of this issue; females have an average of 9.6 while males 9.7. Although the mean of the men is higher than the one of the women, it is important to mention that 7.5% of the men mentioned this problem is not important at all. Both genders think that if this problem is compared with others in the region, the water supply issue is very important or primordial.

Finally, both genders think that the 3 most important topics within the water supply issue are the same ones but not in the same order: the water supply, leaks and water waste, and maintenance of the infrastructure.

AGE ANALYSIS

Perceptions also defer by generations. In this case, I decided to divide the participants into two groups: those that were 45 or less and 46 and older. 42.19% of the residents were younger than 46 years while the rest were older. It is interesting to see that both age groups average the importance of the water supply issue in the Valle de Mexico as the same with a grade of 9.6.

The drinking water preferences behavior is similar but not quite the same. As Figure 6-6 shows, both groups tend to drink water from three different options: 42 lt. jugs, filters, and individual bottles. The figure also exposes that the older generations tend to buy more 42 lt. jugs and filters, while the younger generations buy more individual bottles.

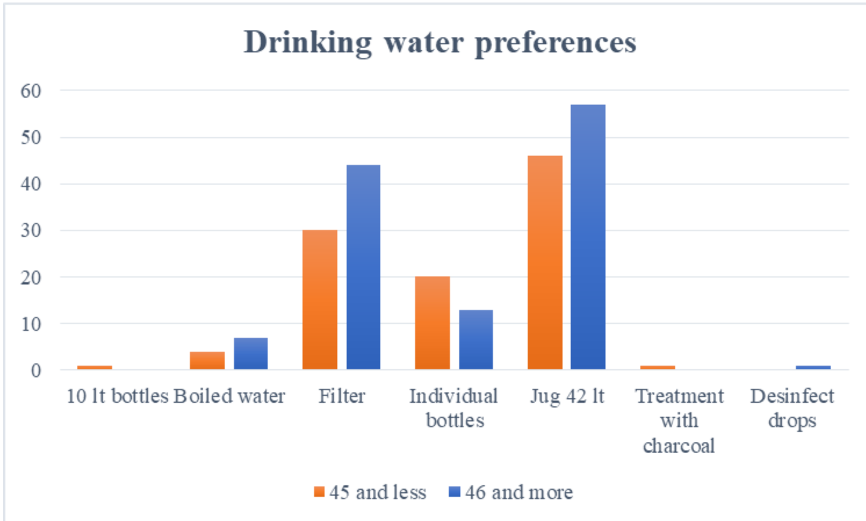

Figure 6-6: Drinking water preferences depending the age of the users.

Regarding the water consumption between generations, Figure 6-7 shows that he participants that drink less than 500 ml per day are in the group of 45 or younger. However, the figure illustrates that 80% of the younger group drink more than 1 lt. per day, while only 72% of the older group drinks that amount of water in a daily basis.

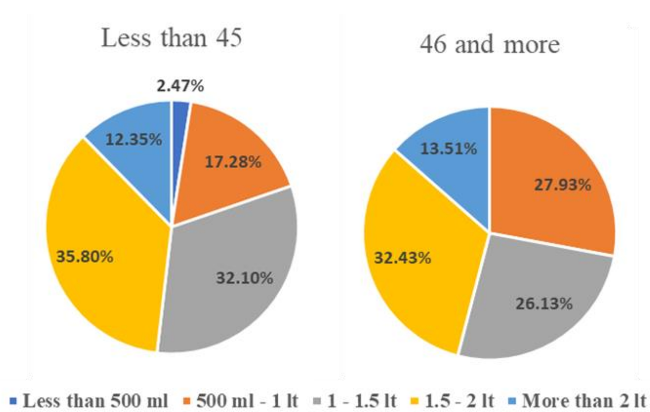

Figure 6-7: Water consumption behavior depending age group.

Solutions to the problem and what are they willing to do to help this issue, also changes between the two age groups. In the case of the first group age, those younger than

46 years, there were more responses that connected “Educations campaigns” to other solutions or actions (Figure 6-8). Also, it is interesting to see that the only mention of electricity in relationship with the water issue, comes from a younger resident. “Fines and penalties” and “desalination of seawater” were solutions proposed only by the younger group. Only 44% of the participants of this younger group responded with the “Don’t know” answer.

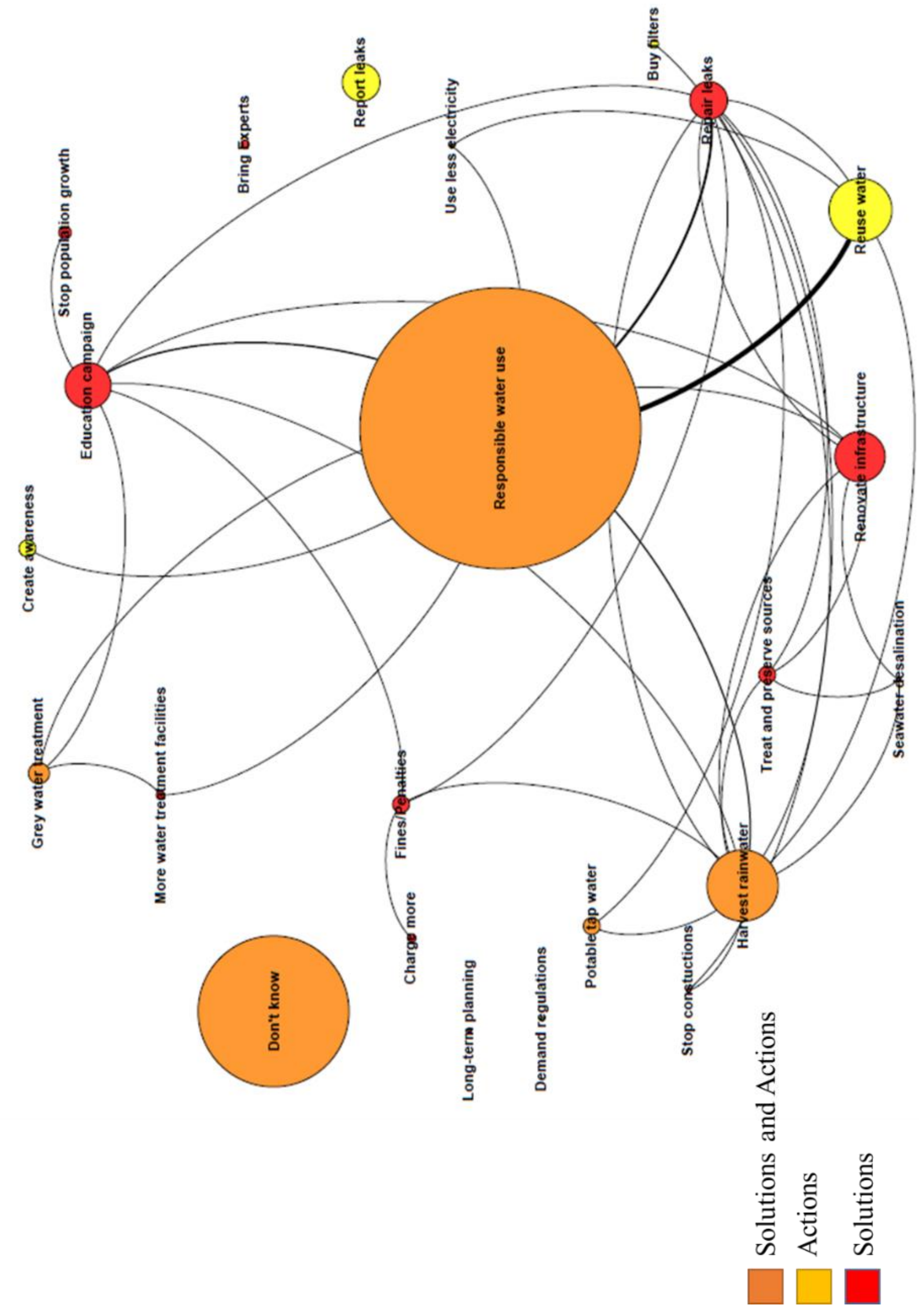

Figure 6-8: Solutions and Actions proposed by the group of 45 and younger participants.

For the older group, 47% of the participants answered “Don’t know” as a response of proposing solutions or mentioning actions they were willing to apply in their daily lives (Figure 6-9). For this group, although education is also important, they had more responses stating that the solution may be related with “renovating the infrastructure” and “repairing leaks” than the younger group. Participants older than 45 years also mentioned as a solution to “stop constructions”, something that the younger group did not responded.

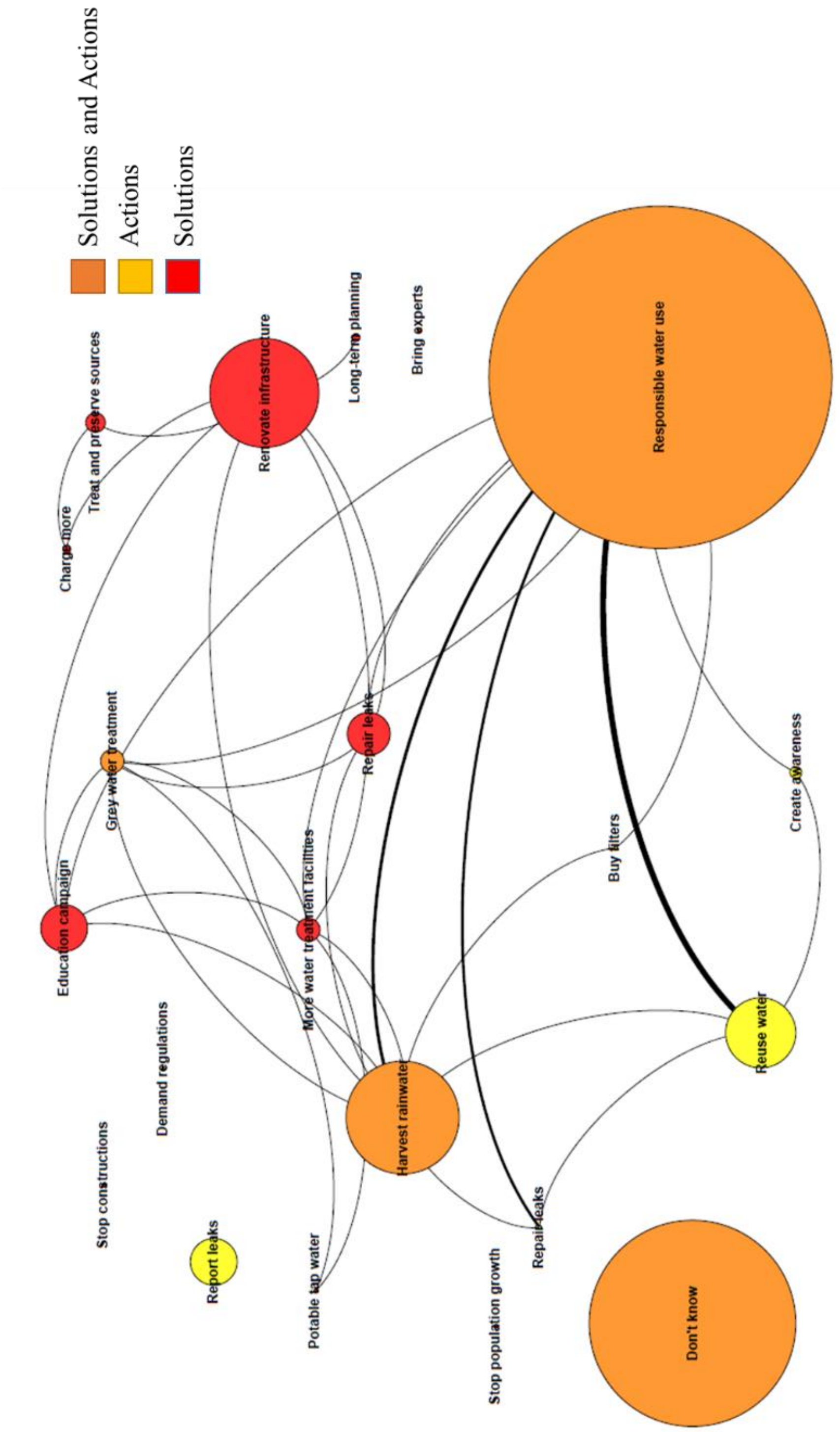

Figure 6-9: Solutions and Actions proposed by the group of 46 and older participants.

REGION ANALYSIS

As mentioned before in previous chapters, the Valle de Mexico is composed of municipalities that are part of two different states: State of Mexico and Mexico City. Although CONAGUA considers the region of the Valle de Mexico as one, it is important to mention that each of the localities are supplied by different municipal Water Agencies and because of this, it is important to see the differences between the user's perceptions in the two different states.

As analyzed in previous sections, 47% of the participants suffered from water shortages. The responses do not differ significantly from the general response when divided between the different locations. 47% of the participants that live in Mexico City suffer water shortages, while in the case of the State of Mexico, the residents that suffer from this same problem is 41%. The 6% difference can be an important one if we take into consideration that this area is a highly populated one, but it is also important to mention that only 12% of the participants live in the State of Mexico so this percentage may be misleading. Figure 6-10 shows the frequency profile for water shortages. Again, it is important to mention that the number of responses in the State of Mexico is relatively lower than the answers from Mexico City. From the figure we can see that in both locations, the most frequent response was "Sometimes". It is also interested to look at the 2.4% of people that responded that they have water shortages every day on the afternoons. Another alarming input is that 11% in the State of Mexico and 15% in Mexico City have water shortages twice or more per week.

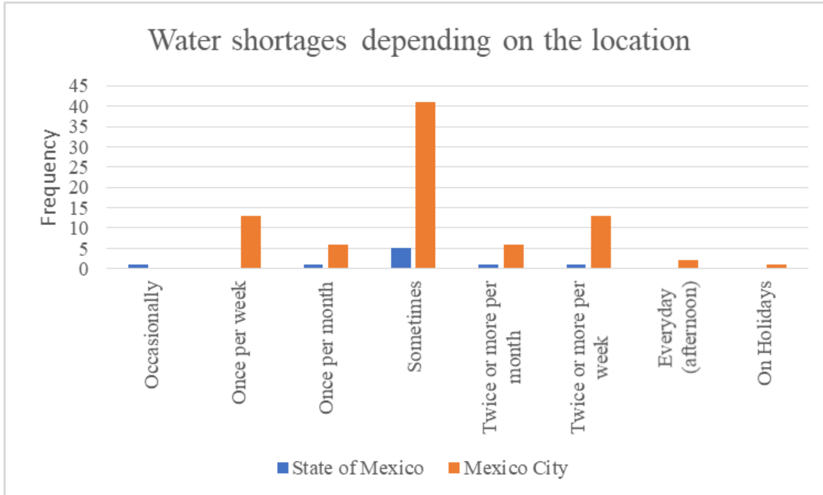

Figure 6-10: Water shortage depending the location of the residents (Canals, 2018)

When the residents were asked to evaluate how much they care about the water supply issue on a scale from 1 to 10, with 1 being very, very little and 10 being very, very much; the average for the State of Mexico was of 9.81 and for Mexico City was 9.63. The follow-up question was to compare the water supply issue to other different problems that the region lives. As Figure 6-11 shows, in both cases, "Very important/Primordial" was the most frequent response. Some of the highlights identified upon closer inspection is that that 3% of the participants from Mexico City answered "Not important at all" and that 4% (Mexico City) and 5% (State of Mexico) respectively answered that "It does not affect me". These responses show the selfishness that some residents have, but also, the lack of information or education in regard of the importance of water. Pretty sure that those participants, do not know how their lives would be affected if water supply stopped in a complete way and the impacts that water has among different sectors and industries. Also, in both locations, "security" was the top- response for other important problems.

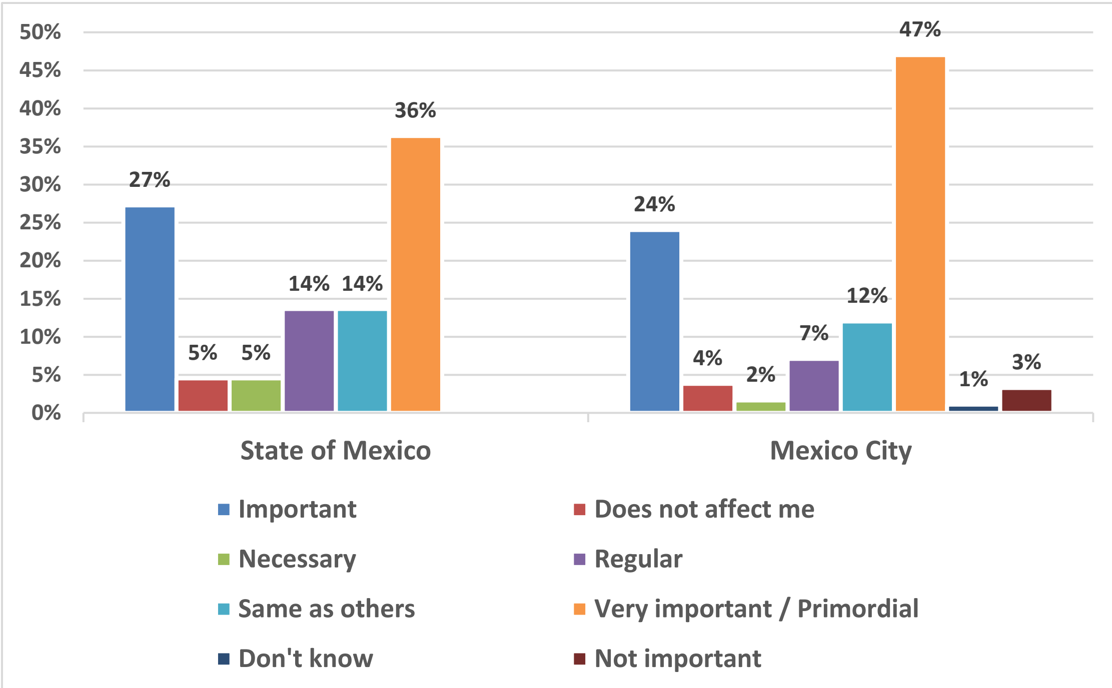

Figure 6-11: Importance of the water supply issue in comparison with other problems of the area depending the location of the participant.

There were various answers residents were asked who should be involved in solving the water supply issue. Often, people do not only answer one specific person or entity but a series of actors that should work together in order to solve this complex problem. The following figure (Figure 6-12) is a conceptual map showing the relationship between the different responses to this question. As previous conceptual maps in this work, the size of the node implies the number of times that specific answer was responded, and the width of the links the times that those two actors were connected in an answer.

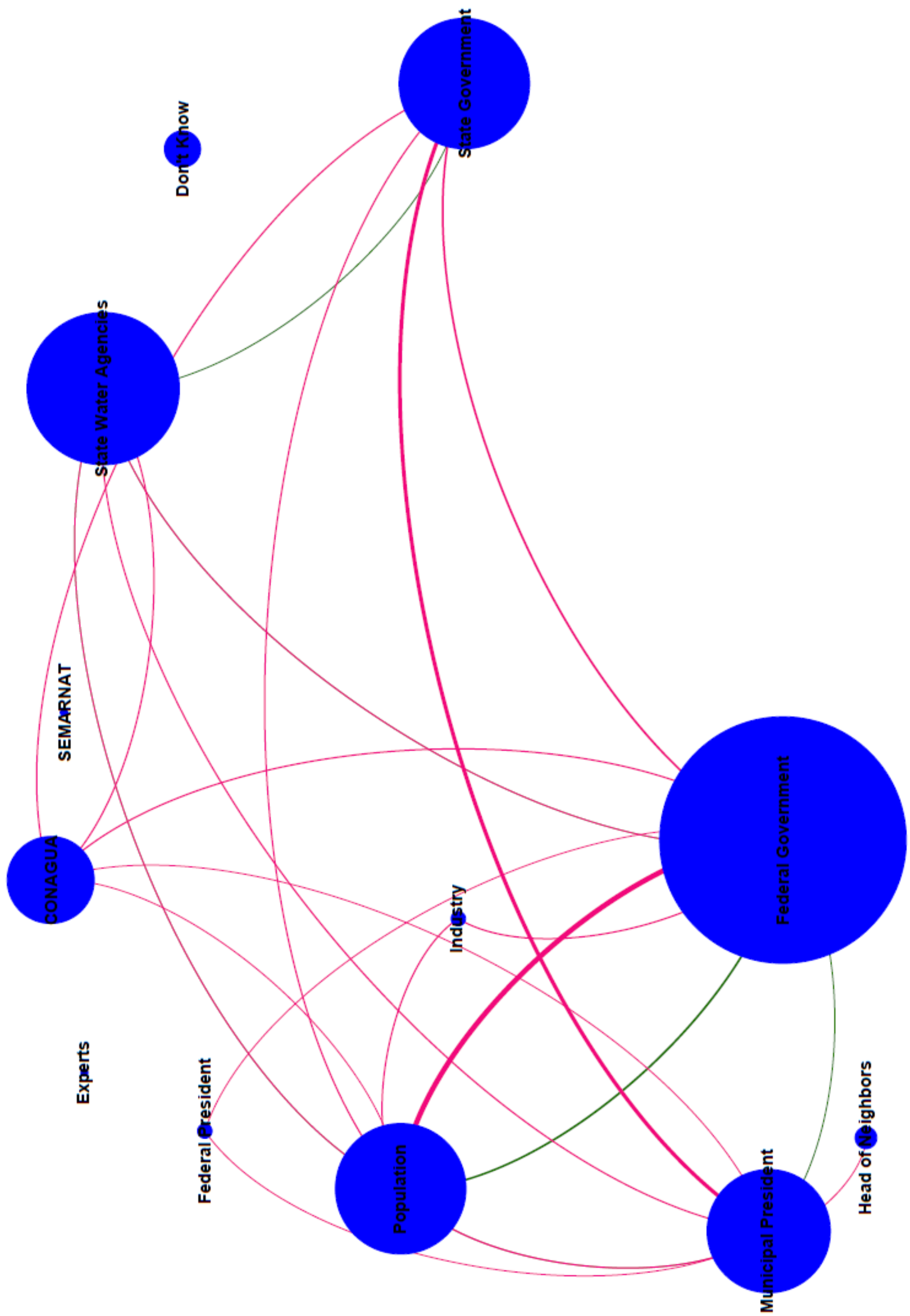

Figure 6-12: Who should be involved? Mexico City vs State of Mexico residents.

As shown in the previous figure, the residents think that it is responsibility of the Federal Government to be involved in the solution of the water supply issue, followed by the State Water Agencies. It is important to mention, that the residents think that the most important synergies should be between the Federal Government and the Population and the Municipal President with the State Government. This is an important discovery, because while the most answered actors were public servers, an important fraction of the population thinks that the population has also an important role in this problem. A more in depth analysis shows that there are a lot of relationships that both, Mexico City's and State of Mexico's residents, believe will be necessary. However, although the responses from the State of Mexico are significantly lower than the ones of Mexico City, there are 3 important relationships that the residents of the State of Mexico think that it is important also to have a communication between the Federal Government and the Municipal President.

As seen earlier, there is a difference between the ideas of solutions that people have and the actions they are prepared to do in their daily lives. Figure 6-13 shows the relationship between the proposed solutions and the actions that the residents of Mexico City are ready to do. As it can be seen, the most important answer that is both, a proposed solution and an action, is the responsible use of the water. It is important to mention, that 23% of the people answered that they did not know a solution or what they could do. Harvest rainwater is something important that residents perceive as a solution or something they would be able to do, but so far there is no existence of any government program that will do this. Besides the ones that were exposed above, the solutions that most residents in Mexico City propose is to renovate the infrastructure and to have education campaigns. The most important actions that the people are prepared to do in their daily lives, besides using water in a responsible way, is to reuse that water and to report leaks. Reporting leaks could be a game changer because as seen in the general situation analysis section, leaks represent almost 40% of the water loss.

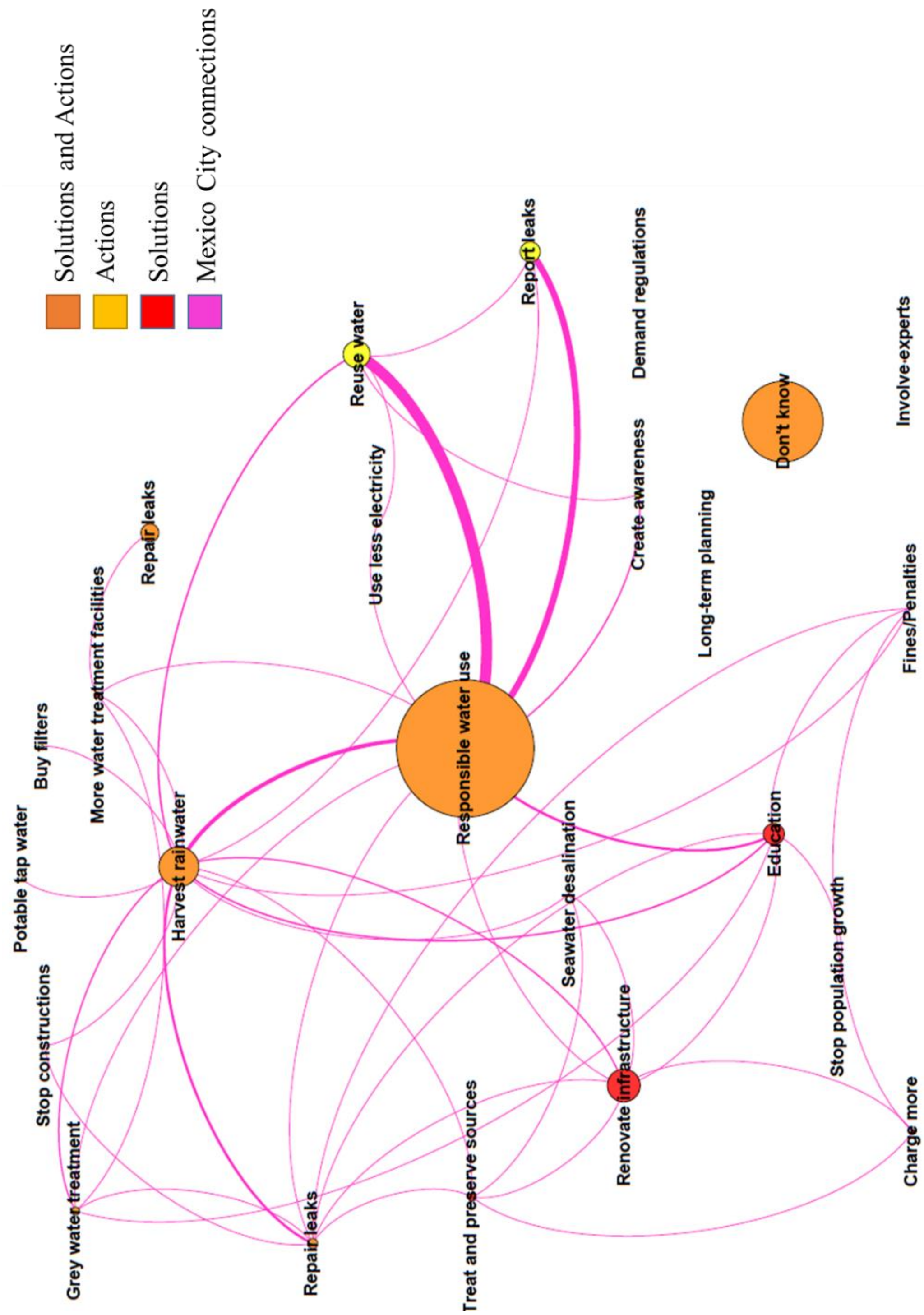

Figure 6-13: Solutions and Actions proposed by the residents of Mexico City.

Doing the same analysis that was done above but with the State of Mexico's responses, figure 6-14 shows again that responsible use of water is the most important action and solution that the residents have in their minds. It was interesting to see that the population of the State of Mexico also thinks about harvesting rainwater, but they see it as a potential solution, not something they are willing to make on their homes. Other perceived solutions are renovate the infrastructure and repair leaks. In the case of the State of Mexico, 20% of the participants responded with "Don't know" to one or both of these questions. Although education is mention, the analysis show that is not as important as other solutions or actions that the residents propose.

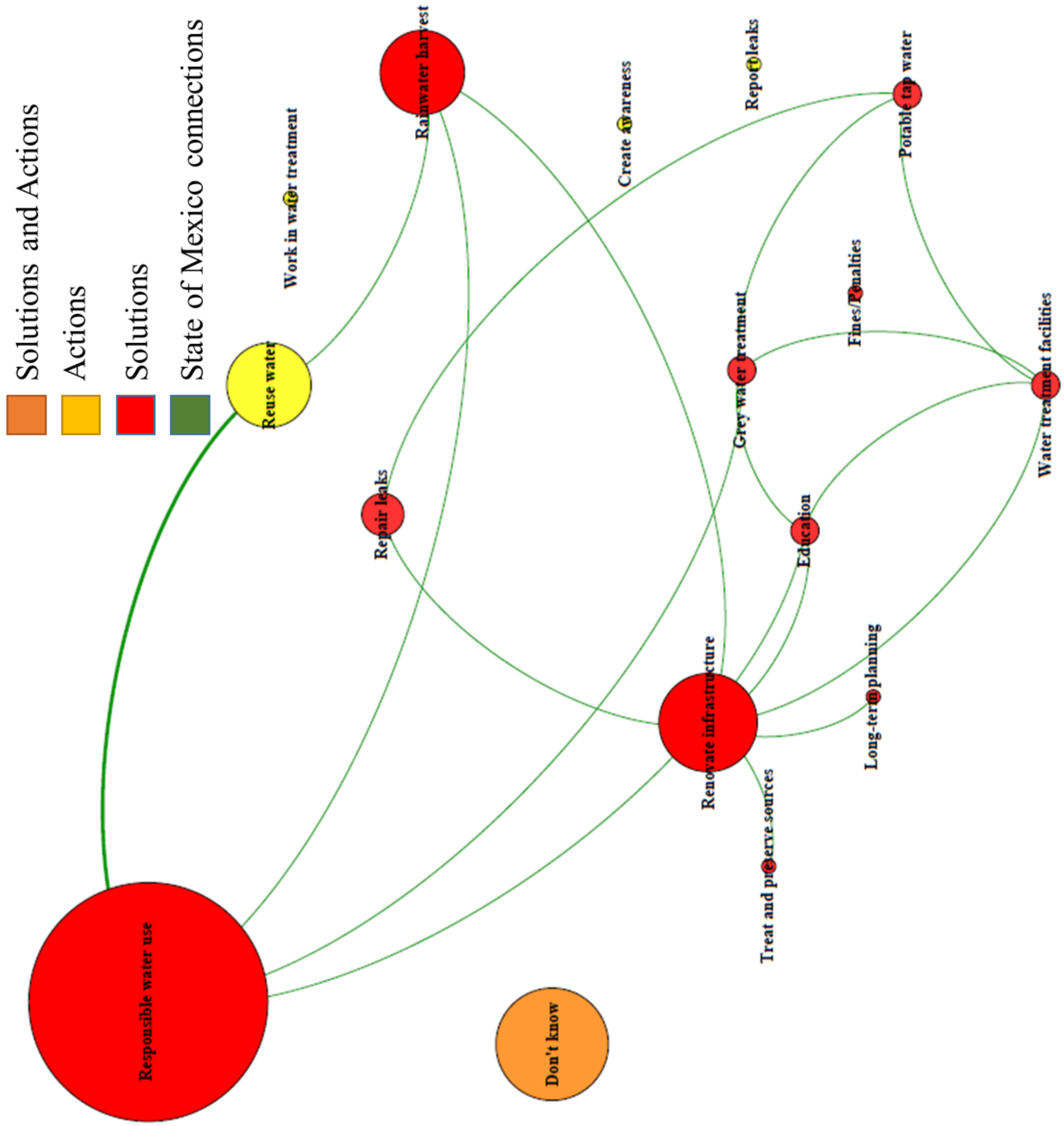

Figure 6-14: Solutions and Actions proposed by residents of the State of Mexico.

Chapter 7: Conclusions

Water security is a rising, complex and important problem around the world,. Analysis of the status of water related issues in the Mexico City Metropolitan area demonstrate that water system and management needs to be addressed in the near term to reduce current inefficiencies and avoid future problems. Water supply decisions and solutions for any city are challenging to make because of the interconnectivity of water to all other sectors and elements of urban living. A simple solution to water problems does not exist, but rather a group of solutions that need to be implemented in the short and long term are necessary. In the Valle de Mexico, most of the decisions and regulations are made by politicians without taking inputs from citizens into consideration or without enough technical information. This research identified general observations about the perceptions, concerns, and aspirations of water users in the basin. Results of nearly 200 interviews documented an initial assessment that may be useful to decision makers in the Valle de Mexico regarding water issues and priorities. This thesis provides preliminary study results that should serve as a basis for further investigation. For further studies, a recommendation is to conduct the surveys and interviews on a larger population with expanded representation of each municipal population. There is a need to extend the study to the missing municipalities of the State of Mexico that were not taken into account in this preliminary research due to safety reasons.

Results indicate that a critical clarification is needed in terms of the description and definition of "water shortage" by delineating the term into two different concepts. The first conceptualization of water shortage is connected to the lack of maintenance of the infrastructure and that 40% of the water that is supplied to the city is lost due to leaks. The second conceptualization of water shortage, relates to the water shortage perceived by the users but also created by their behavior and waste of water without noticing it. Mexico is a country with high water consumption, the fifth country worldwide, and although there is not an exact number of how much water is wasted by the users' behavior, it may be a very high number. Decreasing the waste from the consumers is a difficult challenge because the solution needs to address the core of their daily lives. By having this, the issue can be separated into component concerns that may be more easily treated using different approaches, and when both sub-problems are solved, the general issue maybe resolved.

A key distinction is notable in the data when evaluated across genders. The majority of survey and interview responses result in cohesive perspectives with the exception of the description of the water supply system that resulted in opposing responses divided by gender. A possible explanation relies on the gender-based roles that are common in Mexico. When asked about the cost of water supply men responded that the water supply system is cheap, whereas women feel that the system is expensive. Similarly, male respondents mention that the system is adequate or good for the city, but females indicate that the system is inadequate. In each case, the gender roles may be at play. Most of the bills are paid by men giving them a perception of the water supply from the cost on paper, whereas women tend to remain in the home and experience shortages first hand resulting in a real impact to their daily routines and activities. It's possible that the response to the questions about the value of the supply system is assessed according to different units of measure money versus time or inconvenience.

When the participants were separated in two groups depending on their age, both groups evaluated the water shortage problem with the same average importance of 9.6 and both agree that harvesting rainwater is a viable solution. Younger participants see that the solution should go towards education, seawater desalinization, and implementing penalties and fines for unnecessary water waste. These solutions, if implemented, may help solve or mitigate the water shortages that is perceived and exacerbated by user activities. It is important to highlight that the only answer that connected water with energy was given by one resident of the younger group.

Variation across the different responses reveal that there is a lack of knowledge about the water-energy nexus and that maybe, if the population was aware of this, their behavior or perceptions would change. Older respondents proposed to maintain and renovate the infrastructure, repair leaks, and stop excessive constructions in the area. Solutions identified by the older group target the shortages that are not mitigated by actual management. It is interesting to note, that unconsciously participant groups understand the problems through two different types of water shortage and that the perceptions vary depending on their age group.

When the answers were analyzed by location, the water shortages were almost the same in percentage between Mexico City and the State of Mexico. This indicates, that the problem does not appear to be localized only to the State Water Agency but across the whole supply system. There is slightly more importance given to water shortages in responses from participants in the State of Mexico, but respondents across both locations (4-5%) provided responses that water shortages "does not affect me". Residents from both areas believe that the Federal Government should be involved in the solution and that "responsible water use" from all the players should be taken into consideration. Rainwater harvesting is only perceived to be a solution for the residents of the State of Mexico, while respondents in Mexico City viewed the solutions and actions to be more likely to involve changes that they can apply or implement in their homes.

This study shows a preliminary view into some of the ongoing concerns and challenges faced by the users of a large metropolitan area. The results indicate that the energy-water tradeoffs and the relationship between the water crisis and other issues is not well understood by the vast majority of the urban population. It may be possible, that changing the behavior in both the energy and the water supply from the user side, may have a significant impact in reducing the water shortages and increasing the efficiency and the reliability of the system. All the inhabitants of Mexico, regardless of their actual role, must become primary actors working together on this complex and often intimidating issue.

Appendix A: IRB exception letter

OFFICE OF RESEARCH SUPPORT

THE UNIVERSITY OF TEXAS AT AUSTIN

P.O. Box 7426, Austin, Texas 78713 · Mail Code A3200
(512) 471-8871 · FAX (512) 471-8873

FWA # 00002030

Date: 06/29/17

PI: Suzanne A Pierce

Dept: Jackson School of Geosciences

Title: Water Supply for the Valle de Mexico: providing a feasible space for an interdisciplinary dialogue

Re: IRB Exempt Determination for Protocol Number 2017-04-0072

Dear Suzanne A Pierce:

Recognition of Exempt status based on 45 CFR 46.101(b)(2).

Qualifying Period: 06/29/2017 to 06/28/2020. *Expires 12 a.m. [midnight] of this date.*
A continuing review report must be submitted in three years if the research is ongoing.

Responsibilities of the Principal Investigator:

Research that is determined to be Exempt from Institutional Review Board (IRB) review is not exempt from ensuring protection of human subjects. The Principal Investigator (PI) is responsible for the following throughout the conduct of the research study:

1. Assuring that all investigators and co-principal investigators are trained in the ethical principles, relevant federal regulations, and institutional policies governing human subject research.

2. Disclosing to the subjects that the activities involve research and that participation is voluntary during the informed consent process.

3. Providing subjects with pertinent information (e.g., risks and benefits, contact information for investigators and ORS) and ensuring that human subjects will voluntarily consent to participate in the research when appropriate (e.g., surveys, interviews).

4. Assuring the subjects will be selected equitably, so that the risks and benefits of the research are justly distributed.

5. Assuring that the IRB will be immediately informed of any information or unanticipated problems that may increase the risk to the subjects and cause the category of review to be reclassified to expedited or full board review.

6. Assuring that the IRB will be immediately informed of any complaints from subjects regarding their risks and benefits.

7. Assuring that the privacy of the subjects and the confidentiality of the research data will be maintained appropriately to ensure minimal risks to subjects.

8. Reporting, by submission of an amendment request, any changes in the research study that alter the level of risk to subjects.

These criteria are specified in the PI Assurance Statement that was signed before determination of exempt status was granted. The PI's signature acknowledges that they understand and accept these conditions. Refer to the Office of Research Support (ORS) website www.utexas.edu/irb for specific information on training, voluntary informed consent, privacy, and how to notify the IRB of unanticipated problems.

1. Closure: Upon completion of the research study, a Closure Report must be submitted to the ORS.

2. Unanticipated Problems: Any unanticipated problems or complaints must be reported to the IRB/ORS immediately. Further information concerning unanticipated problems can be found in the IRB Policies and Procedure Manual.

3. Continuing Review: A Continuing Review Report must be submitted if the study will continue beyond the three year qualifying period.

4. Amendments: Modifications that affect the exempt category or the criteria for exempt determination must be submitted as an amendment. Investigators are strongly encouraged to contact the IRB Program Coordinator(s) to describe any changes prior to submitting an amendment. The IRB Program Coordinator(s) can help investigators determine if a formal amendment is necessary or if the modification does not require a formal amendment process.

If you have any questions contact the ORS by phone at (512) 471-8871 or via e-mail at orsc@uts.cc.utexas.edu.

Sincerely,

James P. Wilson

James Wilson, Ph.D.
Institutional Review Board Chair

Appendix B: Questions asked on the survey

(1) What is your age range?
(2) With which gender you identify?
(3) In which municipality you live?
(4) In which state you live?
(5) In what economic sector do you work?
  In case of agriculture: area of the crops; number of different crops
(6) In what range is your typical home water/work bill each month?
(7) How do you use water at your house/work?
(8) What is your drinking water preference?
  (8.a) Range amount of money spend in drinking water
  (8.b) Range amount of water used for drinking
(9) Thinking about your home life and work life, how would you describe how the water supply system in the Valle de Mexico works to someone who does not live here?
(10) What do you think uses the most water (or creates the most demand for water) in the Valle de Mexico?
(11) Do you suffer from water shortages at home or at work?
 If so…
  (11.a) How often do you experience shortages?
  (11.b) What do you do when you suffer from water shortage?
  (11.c) When you suffer a water shortage to whom you go?
(12) On a scale of 1 to 10, with 1 being very, very little and 10 being very, very much, how much do you care about the water supply issue in the Valle de Mexico?
(13) How would you rank the water supply issue in comparison to other issues of the region and why?
  (13.a) Other problems in the region
(14) What is the most question that should be discussed when talking about water in the Valle de Mexico and why?
(15) Do you have ideas about how we can improve the water supply system?
(16) Who must be involved to reduce water shortages?
(17) Is there anything you could do at home or at work to improve water supply in the Valle de Mexico?
(18) Is there anything else you would like to say about water supplies or water uses in the Valle de Mexico?

Appendix C: Approval Letter for the Restricted Regions Travel Request

The University of Texas at Austin
International Office

June 6, 2017

Dear **Regina Montserrat Canals Lopez Velande:**

Thank you for submitting your completed Restricted Regions Travel Request to the International Oversight Committee (IOC). You have requested approval to travel to a Restricted Region, which is an area that poses significant health, safety, or security risks to foreign travelers. The policy of the University of Texas at Austin states that all student travel to locations currently on the UT Restricted Regions List must be reviewed and approved by the IOC prior to departure.

The intent of this IOC review is to provide travelers with information relating to the potential dangers and risks associated with travel to a Restricted Region. In addition, all UT international travelers should understand and be adequately prepared to mitigate the health, safety, and security risks associated with their specific travel to a Restricted Region. Finally, the information collected through this process benefits you and the University in our capacity to provide quality assistance in the event of an emergency or crisis. In cases where the IOC deems the risk to be too high, travel will not be approved.

The IOC has reviewed your submitted materials, and your request to travel to **Mexico City and surrounding metropolitan areas, Mexico** for the time period of **10 July – 18 August 2017** has been **approved**. This means that you may proceed with your planned academic travel to this particular location, which has been recognized as having a significant level of risk. As a condition of approval, the traveler must inform the IOC of any changes to the proposed itinerary, critical nature of the trip, or any other significant modifications to the planned travel.

Please be aware that if there is a change in circumstances – in terms of the proposed itinerary, the critical nature of the trip, or the health, safety, or security climate of the region of interest – either prior to or after your departure, the University retains the right to withdraw this travel approval and/or require your return to the U.S. The University also reserves the right to withhold reimbursement and/or take other disciplinary actions for noncompliance with the UT Travel Policy to Restricted Regions.

Again, thank you for your cooperation with the IOC and for your important contributions to this University. Best wishes for a safe and successful experience abroad.

Sincerely,

International Oversight Committee
Email: IOC@austin.utexas.edu
http://world.utexas.edu/risk/ioc

P.O Box A • Austin, TX 78713-7206 • (512) 471-1211 • FAX (512) 475-6812 • Mail Code: A7000 • http://world.utexas.edu

Appendix D: Survey and interviews results

The surveys and interviews were analyzed using the following code.

1. What is your age range?

    1) 18-25
    2) 26-35
    3) 36-45
    4) 46-55
    5) 56-65
    7) 76-85
    8) More than 86 years

2. With which gender you identify?

    1) Female
    2) Male

3. In which municipality you live?

    1) Álvaro Obregón
    2) Azcapotzalco
    3) Benito Juárez
    4) Coyoacán
    5) Cuajimalpa
    6) Cuahutémoc
    7) Gustavo A. Madero
    8) Iztacalco
    9) Itzapalapa
    10) Magdalena Contreras
    11) Miguel Hidalgo
    12) Milpa Alta
    13) Tláhuac
    14) Tlalpan
    15) Venustiano Carranza
    16) Xochimilco
    20) Atizapán de Zaragoza
    21) Chimalhuacán
    22) Coacalco de Berriozabal
    23) Ecatepec
    24) Huizquilucan
    25) Naucalpan de Juárez
    26) Tlanepantla

4. In which state you live?
    1) Mexico City
    2) State of Mexico

5. In what economic sector do you work?
    1) Agriculture
    2) Industrial
    3) Municipal

6. In what range is your typical home water/work bill each month? (MXN/bimonthly)
    1) Less than $250
    2) $250-$500
    3) $500-$750
    4) $750-$1,000
    5) $1,000-$2,000
    6) $2,000-$3,000
    7) $3,000-$4,000
    8) More than $4,000

7. How do you use water at your house/work?
    1) Personal hygiene
    2) Water consumption
    3) Wash clothes
    4) WC
    5) Kitchen (food, plates, cooking)
    6) Cleaning house
    7) Water pants
    8) Pets
    9) Industrial/Offices

8. What is your drinking water preference?
    1) Individual water bottles
    2) 10 l. bottle
    3) Filter
    4) Jug (42 l.)
    5) Boil water
    6) Disinfect (drops)
    7) Treatment with charcoal

8.a Range amount of money spend in drinking water ($MXN/week)
    1) Less than $100
    2) $100-$200
    3) $200-$300

4) $300-$400
5) $400-$500
6) More than $500

8.b Range amount of water used for drinking
1) Less than 0.5 l.
2) 0.5 l. – 1 l.
3) 1 l. – 1.5 l.
4) 1.5 l. – 2 l.
5) More than 2 l.

9. Thinking about your home life and work life, how would you describe how the water supply system in the Valle de Mexico works to someone who does not live here?
1) Acceptable/Good/Adequate
2) Regular/Sufficient
3) Bad/Deficient/Inadequate
4) Irregular
5) Expensive
6) Depends on economic status
7) Bad water quality/No potable
8) Good quality
9) With many leaks
10) Complex/Complicated
11) Lerma-Cutzamala
12) Aquifer
13) Water comes from other states
14) Cheap/No expensive

10. What do you think uses the most water (or creates the most demand for water) in the Valle de Mexico?
0) Don't know
1) Industry
2) Municipal
3) Commercial sector/restaurants
4) Construction
5) Tourism/Hotels
6) Lack of maintenance/leaks
7) Contamination
8) Population (Lack of education)
    8.1) Children
    8.2) Youth
    8.3) Women
9) Agriculture/Gardens/Parks

10) Companies/Office buildings
11) Hospitals
12) Schools

11. Do you suffer from water shortages at home or at work?
1) Yes
2) No

11.a. How often do you experience shortages?
1) Sometimes
2) On Holidays
3) Occasionally
4) Once per month
5) Twice or more per month
6) Once per week
7) Twice or more per week
8) Everyday (afternoon)

11.b What do you do when you suffer from water shortage?
1) Use my water deposit
2) Save water beforehand
3) Use less water
4) Water tanker
5) Get water from friends and bring it home
6) Buy more drinking water
7) Wait till it comes back/Nothing
8) Go to other places to shower (gym, family, friends)
9) Collect rain water

11.c When you suffer a water shortage to whom you go?
1) No one
2) Water companies/Water tanker
3) Family/Friends/Gym
4) Neighbors
5) Municipal offices
6) Water agencies

13. How would you rank the water supply issue in comparison to other issues of the region and why?
0) Don’t know
1) Very important/Primordial
2) Important
3) Regular

4) Same as others
5) Not important
6) Necessary (will get worse)
7) It does not affect me

13.a Other problems in the region
1) Security
2) Economy
3) Holes in streets
4) Excessive construction
5) Contamination
6) Urban design
7) Traffic
8) Trash
9) Corruption
10) Impunity
11) Population growth
12) Future energy demand
13) Drugs/drug dealers
14) Subsidence
15) Religion

14. What is the most question that should be discussed when talking about water in the Valle de Mexico and why?
0) Don't know
1) Infrastructure/Maintenance
2) Leaks/Waste
3) Water contamination
4) Water quality/potable
5) Water supply
6) Rainwater harvest
7) Grey water treatment
8) Educate the population
9) Control the constructions
10) Sewer system
11) Water rates and tiers
12) City subsidence
13) Population growth
14) Treat and maintain sources
15) Experts
16) Exploit more the aquifer

15. Do you have ideas about how we can improve the water supply system?

0) Don't know/Nothing
1) Responsible use/save water
2) Repair leaks
3) Renovate infrastructure
4) Rainwater harvest
5) Education campaigns
6) Fines/Penalties
7) Stop constructions
8) Grey water treatment
9) Treat and preserve sources
10) More water treatment facilities
11) Potable tap water
12) Charge more
13) Bring experts
14) Stop population growth
15) Desalination of sea water
16) Long-term planning

16. Who must be involved to reduce water shortages?
0) Don't know
1) State water agencies
2) CONAGUA
3) Municipal President
4) Federal Government
5) Population
6) Head of neighbors
7) State government
8) Industry
9) SEMARNAT
10) Federal President
11) Experts

17. Is there anything you could do at home or at work to improve water supply in the Valle de Mexico?
0) Nothing
1) Reuse water
2) Save water/use less
3) Harvest rainwater
4) Report leaks to authorities
5) Buy filters/Build filters
6) Create awareness
7) Use less electricity
8) I work in water purification

9) I work in harvesting rainwater
10) Demand regulations
11) I work repairing leaks.

18. Is there anything else you would like to say about water supplies or water uses in the Valle de Mexico?
0) Nothing
1) Create awareness
2) Harvest rainwater
3) Stop subsidizing water
4) Do not charge if there are water shortages
5) Change regulations
6) Fines for waste
7) Improve infrastructure
8) Drinking quality in tap water
9) Grey water treatment
10) Stop constructions
11) Have experts

The following are the raw data of the surveys.

ID	Age Range	Gender	Municipality	Zip code	Mexico City (1) / State of Mexico (2)	Water bill ($/bimonth)	Economic sector	Crops	Water Uses	Drinking water preference	Drinking water consumption (liters)	Drinking water bill municipal ($/week)
1	4	1	3	03300	1	2	3		6	3	4	1
2	4	1	2	02800	2	3	3		3,4,6,7	4	3	2
3	4	1	20	52990	2	3	3		6	4	2	1
4	4	1	16	16010	1	1	3		6	4	5	2
5	4	1	25	53310	2	3	3		1,4	3	3	1
6	4	1	26	54080	2	2	3		3,4,5	4	2	1
7	4	1	25	53100	2	4	3		1, 3, 5, 6, 7	4	3	2
8	4	1	26	54050	2	3	3		3,4,5	4	4	3
9	1	2	14	14210	1	7	3		1,6	3	3	4
10	1	1	14	14200	1	2	3		6	3,5	4	4
11	1	2	14	14648	1	1	3		1,4	1,3,4	3	2
12	1	2	24	52788	2	6	3		3,4,7	3	3	6
13	2	2	11	11000	1	6	2		4,9	1	3	
14	3	1	6	06400	1	1	3		1,5	3	3	3
15	2	1	24	52779	2	4	3		1,4,6,7	3	4	1
16	1	2	1	01430	1	1	3		1,3,4,5,7	1,3,4	4	2
17	2	2	15	15900	1	5	3		6	3,4	3	4
18	1	2	3	03100	1	2	3		1,6	4	3	1
19	2	1	3	03100	1	3	3		1,6	4	4	3
20	1	2	4	14410	1	3	3		2	3	3	1
21	3	1	25	53140	2	2	3		6	4	3	2
22	1	2	3	03810	1	2	3		1,3,6	3	4	1
23	2	2	24	66215	2	1	3		1	4	2	6
24	2	2	26	54020	2	2	3		1,2,3	3	4	1
25	2	2	22	55710	2	2	3		1	1	2	2
26	4	2	1	01700	1	4	3		6	4	5	2
27	3	1	1	01430	1	4	3		1	4	4	4
28	3	1	11	11800	1	1	3		3,5,6	1,4	4	2
29	4	1	1	01620	1	2	3		6	3	4	1
30	4	1	1	01710	1	2	3		1,4,5	3	3	4
31	4	1	14	14140	1	1	3		4,5,6	3	3	1
32	4	1	16	16034	1	1	3		6	4	3	1
33	2	1	6	06170	1	2	3		6	4	4	2
34	4	2	4	04930	1	2	3		1,6,7	4	4	1
35	4	2	4	04100	1	3	3		1,2,4,6,7	3	4	1
36	5	2	11	11800	1	2	3		1,4,6	1	3	3
37	4	1	24	52763	2	6	3		1,3,4	4	3	2
38	5	1	4	04470	1	2	3		1,3,4,5,6	3	5	5
39	4	1	10	10200	1	4	3		1,2,4	3	2	3
40	4	2	10	10200	1	5	3		4	3	4	4
41	4	2	4	04980	1	1	3		3,5	3	3	1
42	5	1	10	10200	1	2	3		1,2,3,4	3	2	1
43	2	2	1	01210	1	1	3		1,5	3	3	1
44	4	1	4	04000	1	5	3		1,5	4	3	2
45	5	2	3	03810	1	1	3		2,4,6	3	2	3
46	4	1	1	01330	1	2	3		4,5,6	3	3	2
47	3	2	3	03340	1	2	3		1,3,6	3	4	1
48	5	2	3	03100	1	1	3		1,3,4,6	3,4	4	1
49	4	1	1	01710	1	4	3		1,3,4,5,6	3	5	1
50	4	1	4	04318	1	5	3		6	4	3	4
51	5	2	1	01900	1	6	3		1,4,5,6	3	3	3
52	4	1	1	01700	1	1	3		1,3,6	4	3	2
53	2	1	14	14330	1	1	3		1,2,3,5	3	3	1
54	2	1	4	04300	1	1	3		3,4	4	3	2
55	5	1	1	01710	1	2	3		4,5	3	3	1
56	5	2	23	55050	2	1	3		1,4,5,6	4	2	1
57	4	1	3	03240	1	2	3		2,3,5,6,7	3	3	1
58	5	1	1	01900	1	5	3		3,4,6	4	3	1
59	2	1	6	06400	1	1	3		1,4,6	4	4	1
60	4	1	14	14420	1	2	3		1,2,6,7	4	2	1

ID	Age Range	Gender	Municipality	Zip code	Mexico City (1) / State of Mexico (2)	Water bill ($/bimonth)	Economic sector	Crops	Water Uses	Drinking water preference	Drinking water consumption (liters)	Drinking water bill municipal ($/week)
60	4	1	14	14420	1	2	3		1,2,6,7	4	2	1
61	4	1	10	10400	1	1	3		4,6	4	2	2
62	4	1	10	10400	1	1	3		4,6	4	2	2
63	5	1	1	01760	1	6	3		2,4,6	4	4	2
64	5	1	4	04200	1	5	3		6	4	2	2
65	5	1	4	04040	1	4	3		1,3,4,6	3	5	4
66	5	1	8	08830	1	2	3		3,5,6	3	2	2
67	3	2	3	03200	1	1	3		2	1,3	2	1
68	4	2	24	52786	2	6	3		1,5,7	4	3	3
69	4	2	1	01900	1	3	3		6	3	4	2
70	2	2	1	01620	1	2	3		4	1	5	3
71	4	1	3	03100	1	2	3		4,5	4	2	1
72	4	2	7	07510	1	1	3		6	4	2	1
73	5	1	14	14620	1	6	3		1,3	3	2	3
74	5	1	3	03810	1	2	3		1,3,5,6	4	4	2
75	5	1	14	04900	1	1	3		6	4	3	3
76	4	1	3	03910	1	2	3		4,5,6,7,8	3	3	1
77	4	1	9	09870	1	2	3		1,4,6	4	4	3
78	4	1	14	14210	1	3	3		4	1	2	2
79	2	1	7	07800	1	2	3		6	4	3	3
80	4	2	11	11000	1	8	3		6	3	3	3
81	3	1	4	04250	1	3	3		6	4	4	1
82	4	1	1	02790	1	2	3		1,6	4	2	1
83	3	1	4	04450	1	4	3		1,5,6	1,3,4	2	3
84	2	1	1	01900	1	1	3		1,3,4	3	5	1
85	2	1	3	03810	1	3	3		1,3,4,6	1,4	3	2
86	1	2	7	07010	1	4	3		6	4	4	2
87	4	1	3	03650	1	8	2		1,4,7	1,3	2	
88	5	1	14	14600	1	3	3		6	5	4	1
89	5	1	14	14420	1	2	3		1,3,4,5,6	4	4	1
90	4	1	1	01060	1	7	3		6	3	4	6
91	3	1	11	11800	1	2	3		1,3,4,5	1,4	3	2
92	2	1	15	15820	1	4	3		1,3,4,5,6,7	1,4	4	3
93	2	1	9	09410	1	2	3		1,6	1	4	2
94	5	2	15	15000	1	2	3		1,4,5,6	4	5	1
95	5	1	4	04120	1	1	3		1,3,4,5,6	4	3	1
96	5	1	10	10200	1	5	3		6	5	2	2
97	4	1	4	04100	1	5	3		1,2,3,4,6	3	3	1
98	3	1	11	11800	1	1	3		1,3,5	2	4	1
99	4	1	1	01040	1	2	3		6	4	2	6
100	5	1	1	01030	1	6	3		1,3,5	4	5	6
101	5	2	6	06700	1	6	3		6	4	5	2
102	5	2	15	15530	1	2	3		6	3	2	1
103	5	1	4	04310	1	6	3		1,3,5	3	4	5
104	3	2	25	53310	2	3	3		1,6	1	5	1
105	5	2	11	11570	1	3	3		1	4	3	1
106	5	1	25	53140	2	3	3		1,3,4,6,7	1,4	3	1
107	5	1	3	03330	1	2	3		1,4,5,6	4	5	1
108	4	1	4	04100	1	5	3		1,3,5,6	3	2	1
109	2	1	4	04320	1	3	3		2,3,6	5	1	2
110	6	2	4	04010	1	3	3		1,3,4,5,7	3	2	2
111	5	1	3	03100	1	1	3		1,4,5,6	5	3	1
112	5	2	11	11230	1	2	3		1,2,4,5	1	2	2
113	3	2	1	01710	1	5	3		6	3	2	3
114	6	1	4	04310	1	1	3		6	1	2	1
115	1	1	4	04320	1	1	3		1,4,5	4	3	1
116	2	1	14	14350	1	2	3		1,3,4	1,3,4	2	3
117	3	1	4	04300	1	4	3		1,3,6	1,4	4	2
118	3	1	9	09780	1	5	3		1,3,4,5,7	4	4	3
119	3	1	11	11340	1	2	3		6	4	2	3
120	4	2	3	03100	1	5	3		1,4,6	4	4	3

ID	Age Range	Gender	Municipality	Zip code	Mexico City (1) / State of Mexico (2)	Water bill ($/bimonth)	Economic sector	Crops	Water Uses	Drinking water preference	Drinking water consumption (liters)	Drinking water bill municipal ($/week)
121	3	1	1	01710	1	5	3		1,4,6	4	4	3
122	4	1	3	03020	1	2	3		1,3,4,6	6	4	1
123	5	2	1	01030	1	8	3		1,3,6	4	3	2
124	4	1	10	10340	1	3	3		1,3,4,5,6	3	2	2
125	1	2	3	03920	1	3	3		6,7	1	3	4
126	4	2	7	07210	1	2	3		1,3,4,6	4	2	1
127	4	1	3	03740	1	2	3		6	3	4	1
128	3	1	14	14400	1	1	3		1,3,4,6	4	2	1
129	3	2	1	01650	1	2	3		1,3,4,5	3	5	1
130	5	1	13	13270	1	2	3		4,6	4	4	3
131	2	1	20	52918	2	2	3		1,3,5,7	3	3	1
132	2	2	4	04369	1	3	3		4	4	3	1
133	3	1	6	06300	1	2	3		6	4	2	1
134	4	2	21	56330	2	3	3		6	4	4	2
135	4	1	10	10020	1	1	3		1,2,3,4,5,6,7	3,4	2	1
136	4	1	7	04170	1	3	3		6	4	4	2
137	1	1	11	11000	1	6	3		6	4,5	3	3
138	1	1	11	11800	1	4	3		1,5,6	1,4	4	1
139	3	2	3	03020	1	1	3		1,4,5	3	3	1
140	3	2	10	10020	1	1	3		6	4	5	3
141	1	1	3	03020	1	5	3		1,2,4,5	3	4	4
142	2	2	3	03100	1	2	3		1,2,5,6,7	4	2	1
143	2	1	8	08000	1	3	3		6	4	3	2
144	5	1	4	04310	1	2	3		1,5,6	3	3	3
145	1	2	11	11910	1	7	3		1,4,7	3,4	5	4
146	3	1	2	02950	1	5	3		6	3	5	4
147	2	1	6	06900	1	2	3		1,4,5	4	3	1
148	3	1	2	02150	1	2	3		2,6	4	2	3
149	4	1	6	06670	1	2	3		1	4	4	1
150	4	1	20	52970	2	2	3		1,2,3,4,5,6,7	3	3	1
151	3	1	3	03300	1	1	3		1,2,3,4,5	3	4	1
152	4	1	11	11000	1	2	3		1,4,6	4	2	3
153	4	1	3	00320	1	3	3		2,3,4,6	3	3	1
154	5	1	3	03100	1	2	3		4,6	4	5	2
155	4	1	3	03100	1	2	3		2	3	5	2
156	4	2	11	11560	1	1	3		6	3	3	1
157	5	2	3	03100	1	3	3		1,2,3,4,5,6	4	3	1
158	4	1	10	10200	1	4	3		1,3,4,6	4	5	4
159	3	2	7	07830	1	4	3		6	3	1	2
160	3	1	3	03910	1	2	3		5,6	3	4	3
161	4	2	6	06030	1	4	3		4,5	3	4	1
162	2	1	7	07830	1	3	3		3,6	4	2	1
163	3	1	11	11400	1	1	3		1,3,4,5,6	4	4	1
164	2	2	6	06880	1	3	3		1,4,6	4	3	6
165	3	1	3	03100	1	4	3		1,2,4,5,6	7	4	1
166	4	1	3	03100	1	2	2		4	1,4	2	
167	2	1	3	03700	1	2	3		1,3,4,5,6	4,5	3	1
168	4	1	20	52990	2	2	3		1,2,3,4,5,6	3	2	2
169	3	1	7	07830	1	2	3		6	4	4	1
170	5	1	24	52785	2	4	3		1,2,3,4,5,6,7	3	4	2
171	3	2	1	01900	1	1	3		4,5	3	5	1
172	5	2	14	14300	1	2	3		6	1,4	3	1
173	3	2	9	09070	1	8	2		9	1	5	
174	4	2	9	09810	1	8	2		5	1	4	
175	4	1	14	14210	1	5	3		1,3,6	4	5	3
176	7	2	14	14210	1	4	3		6	3	4	1
177	4	1	10	10500	1	7	3		1,3,5,6	4	3	2
178	2	1	9	09470	1	4	3		1,4,5	1,4	3	3
179	3	1	15	15300	1	2	3		6	1	2	1
180	4	2	14	14400	1	2	3		6	1,4	4	1
181	2	2	3	03340	1	2	3		4,6	4	5	1
182	6	2	12	12070	1	7	1	4: corn, carrot, tomato, onion	2,7	1,5	5	
183	4	1	5	05600	1	7	3		1,2,3,4,5,7	3	3	1
184	2	1	9	09099	1	1	3		1,3,4,5	4	3	1
185	2	1	6	06500	1	1	3		1,3,4,5	4	3	1
186	2	1	2	02070	1	1	3		3,4,5	4	2	1
187	6	1	3	03700	1	2	3		1,3,4,5,6,7	1,4	3	2
188	8	2	16	16058	1	2	1	Various flowes and 7 edible plants: tomatoes, onions, lettuce, purslane, spinach, parsley, cilantro	7	1,5	4	
189	5	1	1	01760	1	3	3		5,6	5	2	1
190	2	2	24	52764	2	3	3		1,2,4	3	3	2
191	5	2	11	11910	1	7	3		1,3,4,6,7	4	4	3
192	7	1	11	05120	1	1	3		1,3,6	4,5	5	1

ID	Drinking water bill agriculture/ industrial ($/week)	Water system description	Creates Demand	Water Supply shortages?	Frequency (Times per year)	Actions	To whom you go?	Who should be involved?
1		1	5	1	1	2	4	6
2		1	1	1	1	2,6	1	4
3		1	2	2				6
4		4,6	1	1	1	1	1	3
5		11	2	1	1	1	1	1
6		1	0	1	3	3	1	0
7		1,7	1	1	1	3	1	1,4,5
8		1	2	2				1
9		1	2	2				4
10		3	0	2				11
11		1	8	2				2,4
12		2	1	2				5
13	6	3	0	1	1	1	5	0
14		3	1	1	7	4	1	4,7
15		2,7	2	2				2,4
16		4,7	1	1	1	5	5	4
17		6	1	1	1	1	1	4,5,8
18		1	4	1	1	2, 3	2	3
19		2	1	2				3
20		6	1	2				9
21		1	0	2				4
22		3,7	1	2				4,5
23		2	1	2				2
24		1	2	1	1	2	4	5
25		2	0	1	4	4	2	1
26		3	3	1	1	4	4	4
27		3	1	2				4,5
28		2,7	8	1	5	2, 3	2	3,7
29		2	3	1	1	2, 3	2	11
30		2	10	2				3,4,7
31		1	10	2				4
32		3	8	2				4
33		1	2	2				7
34		1	2	2				3
35		3	1	2				4,7
36		3,5	4	1	1	6, 8	1	3,7
37		3	2	2				5
38		7	0	2				0
39		1	2	2				5
40		1	1	2				3
41		1	1	1	1	2, 3	4	1,3
42		1	1,3	2				5
43		4	1	1	1	7	1	4
44		2	8	2				7
45		4,7	3,5,6	2				4
46		10	0	2				4,5
47		6	8	2				5
48		3	1	1	6	1	1	0
49		1	0	2				3,4,7
50		5	0	1	1	4	1	4,7
51		2,7	2,10	2				4,5
52		6	1,6	2				4,5
53		3	1	2				1,7
54		3	8	1	5	2	2	4
55		2	8	2				4
56		1,6	1	1	1	4	3	7
57		3	1	1	6	3	5	5
58		6	1	2				4
59		1,7	8.3	2				1
60		6	6,8	1	1	1, 4	6	1,2,4

ID	Drinking water bill agriculture/ industrial ($/week)	Water system description	Creates Demand	Water Supply shortages?	Frequency (Times per year)	Actions	To whom you go?	Who should be involved?
61		3	1	1	6	3	1	4
62		3	1	1	6	3	1	4
63		1	1	1	1	4	5	1
64		1	1	1	1	6	1	1,3
65		2	1	2				7
66		1	1	2				7
67		5,6	2,3	1	1	3, 4	2	4,5
68		3	6	1	1	1	5	1,7
69		2	2	1	1	3	2	2
70		3	0	1	1	2	6	7
71		3	1	1	4	4	2	2,7
72		1	1	2				1
73		3,7	1	1	4	1	1	4,5
74		1	0	2				1,5
75		3	1,3,5	1	1	4	5	2,3
76		1,4	4	1	7	1	1	1
77		2	8	1	1	4	5	0
78		3,7	9	2				5
79		3	1	2				2
80		1	10	2				4,5
81		3	1	2				4
82		3	2	2				2
83		2	2,3,10,11	1	6	3	1	5
84		2	2	2				4
85		10	8	2				4,5
86		1	10	2				5
87	6	3,5	2,6	1	4	1	2	3
88		3	1	1	1	4	5	3,5,7
89		2	1,3	2				7
90		1	1	1	1	3, 6	5	3,6
91		1	1	2				4,5
92		1,6	8.3	2				1
93		3	8,10	1	5	1	3	7
94		1,6	1	2				4,5
95		2	1	2				2,5,7
96		3	2	2				5
97		13	1	2				5
98		3	1	2				4,7,8
99		3	1	1	1	6	5	5
100		1	1	2				4,5
101		3	4	1	7	4	2	3
102		11,12,13	5,10,11	2				2
103		2	4	1	1	1	2	1,5
104		1,8	1	2				3,7
105		1	1	2				4
106		1	3	2				5
107		3	0	1	8	2	1	4
108		4	8	1	6	1	4	1
109		3,7	2,4	2				4
110		3	8	2				4
111		2,6	1	2				1
112		1	2	2				4,5
113		1	8	1	1	4	2	4
114		3	1,3	2				11
115		1,7,14	1	2				3,5,11
116		2	1	2				4,5
117		2	10	1	7	5	4	4
118		4	8	1	1	6	5	7
119		1	1	2				1
120		3	10	1	7	1	5	0

ID	Drinking water bill agriculture/ industrial ($/week)	Water system description	Creates Demand	Water Supply shortages?	Frequency (Times per year)	Actions	To whom you go?	Who should be involved?
121		3,5	4	2				3,7
122		2	3,4	1	1	2	1	4
123		1	1	2				1
124		3	1	1	6	6	2	1
125		2	4	1	4	4	2	2
126		4	10	1	7	2	1	1
127		1	2	2				5
128		4	10	1	6	3	4	1
129		2	3,5	1	6	6	1	3,7
130		3,5	1	2				1,2
131		2,9	3	1	7	1	6	4
132		2	2	2				4
133		3	3,12	1	6	2	2	4
134		2	1	1	5	7	2	1,3,4
135		4	2	2				2
136		3	6	1	6	2	5	4
137		5	2	2				4
138		2, 7	4	1	1	2	1	2
139		1	2,4,10	2				4,5
140		3	8	1	7	4	5	4
141		3	2	2				1,2
142		11,12	9	1	1	2	1	1,2
143		3	1	1	1	1	1	4
144		3	2	2				4
145		3,5,6,7	1	2				1,7,11
146		2	10	1	1		5	4,5
147		3	8	1	6	2	3	7
148		3	1	1	7	7	5	6
149		2	1,3	1	6	8	3	1
150		1	3	2				1
151		4	1	1	4	4	6	2,5
152		3,6	2	1	1	5	2	1
153		1	0	2				1,3,4,5,7
154		3,9	1	2				5
155		1	8.1,8.2	1	1	4	5	3,5,7
156		2	6	1	7	1	1	3
157		1	1	1	1	2, 4	2	2,4
158		10	2	2				3,7,9
159		1	8	1	1	6	1	4,5
160		1	8	2				4
161		1,6	1	2				7
162		3	1	1	1	2	1	5
163		1	8	2				5
164		4	3,10	1	1	4	2	9
165		3,5	1	1	2	2	1	2
166	2	11	8	2				4
167		1	9	2				5
168		1	9	2				3,7
169		2	3	1	8	3	1	4
170		1	0	2				4
171		6,10	1	1	1	1	3	4
172		1	1	2				3,7
173	6	4,7	6	1	7	4	2	4,7
174	6	3	2	1	7	7	1	1
175		7	1	1	5	7	3	2,7
176		1	3,4,5	2				1
177		1	1	2				4
178		3	4	1	4	8	3	3,10
179		6	8	2				1
180		3	6	1	7	1	2	1
181		3	1	1	5	2	1	4,5,8
182	2	11	8	1	5	5, 9	1	4,10
183		1,6	0	2				5
184		2	1,3,5	1	1	1	1	4
185		3	4,5,8,9	1	7	4	6	4,5
186		3	2	2				4,11
187		6	1,3	1	1	2, 3	5	1,2,3,5,7
188	2	11,6	1,7	2				5
189		6	1	2				5
190		1	1	2				5
191		11	1,2,8	2				1,4
192		1	8	2				2,10

ID	Importance	Importance in comparisson	Other important problem (Notes)	Most important topic?	Solutions	What can you do?	Any more comments
1	10	1		11	3	1,2	2,11
2	8	6		13,14	5,8	0	0
3	10	6		5,8	3,4	1	10
4	10	2		4	3,4	2,3	8
5	6	7		3	8,10,11	2	1
6	9	1		1,2,8	3	2	0
7	10	2	1,3	1,7,8	3,5,10	1,2	0
8	9	2	4	9	3,9	1,2	7
9	8	4		5	0	2	0
10	8	2		3,4	13	1,2	0
11	10	1		5,8	0	2	0
12	6	3	1,5,7	7,10	0	0	0
13	2	5		1,11	0	0	0
14	10	1		1,6	9	1,2,3	1,5
15	10	1		4,5	2,3	0	1
16	10	1		3,16	4,11	3	7
17	10	1		13	5,14	2	1
18	7	1		1	9	4	0
19	10	2		8	1,5	2	10
20	9	1		4	8	3,5	0
21	10	4		4	1	2	0
22	9	1		5	3	2	0
23	10	2	1,2	4	2,11	6	0
24	7	1		5	6	2	0
25	8	3	1,9	5	0	2	0
26	10	5		2	2,4	2	0
27	10	1		1	0	0	7
28	10	1		1,6	3	2	0
29	10	2		2	3	2	1,7
30	8	1		5	0	0	0
31	10	1		9	10	2	0
32	10	1		4,5	9	0	6
33	10	1		1	1	2	0
34	8	1		4	0	2	0
35	10	1		2,6	3,4	2,3	0
36	10	1		1	1	2	0
37	10	1		6	0	2	1
38	8	1		3,4,5	0	2	0
39	10	1		4,5	4	2	0
40	8	1		2	3	0	0
41	10	2		0	0	0	0
42	10	1		2	0	2	0
43	8	2	1	0	0	5	0
44	10	1		4,5	3	2	0
45	10	1		1,2	2	4	0
46	10	1		2,6,7	0	2	1
47	8	1		1,6	4	1,2	0
48	9	1	11	2	0	0	2
49	10	1		5	0	1,2	0
50	10	7		1	12	2	0
51	10	1		1,2,8	3,5	1,2	0
52	10	2		2	2	2,4	3
53	10	1		2,5	0	2	0
54	10	3	1	0	1	2	0
55	10	1		13	0	2	0
56	9	1	1	2	4	2	0
57	10	1		3,4,5	0	6	0
58	9	4		5	0	0	0
59	10	2		4,5	2,5,6	1,2,4	1
60	10	1		4,5	0	2	1,5,7

ID	Importance	Importance in comparisson	Other important problem (Notes)	Most important topic?	Solutions	What can you do?	Any more comments
61	10	1		1	3	4	0
62	10	1		1	3	4	0
63	10	1		1	2	2	0
64	10	7	1	3,13	0	2,3	7
65	10	1		1,5	0	2	0
66	9	1		5	5	1	0
67	10	2	1	1,2,4	0	2	0
68	10	4	1,7	2,7	4	9	7
69	10	3		4	3	2	0
70	10	1		10	3	2	0
71	10	1		2,5	0	0	0
72	9	5		2,8	3	2	0
73	10	1		8	3	0	3
74	6	2		0	0	2	0
75	10	1		5	3,9,12	1,2	1
76	10	2		3	9	2	7
77	10	2		5	0	1,2	0
78	9	3	1	2	2	1	0
79	9	1		8	10	2	0
80	10	7		2	16	2	0
81	10	2		1	5	2	0
82	10	2		2	3	2	0
83	10	1		1,8	4,6	2	0
84	8	1		1	3	2	0
85	10	1		1,2,10	5	2	0
86	9	1		4,5	1,5	8	0
87	8	0		2,9	3	1,2,3	0
88	10	1		2,10	0	2,4	0
89	9	2		2,7,10	3	0	0
90	8	3		8	13	6	0
91	9	2		2	0	2,4	0
92	10	2		5	3,4,9,15	1,2	0
93	10	1		2	1,3,5	2	0
94	9	1		1	0	0	1,11
95	9	3	1,9,10	9	0	1,2,4	1
96	10	1		5	0	2	0
97	8	1		1	4	2	1,2
98	5	6	12	3,4,5	0	2	1
99	1	2		5	1	2	0
100	10	7		5	0	2	0
101	8	4		9	1,10	2	0
102	9	3	1,13	8	7	2	5,6
103	10	1		2	2	2	0
104	10	1		12	1,5,8	3	1,2
105	10	1		0	3	2	1
106	8	1		5	0	0	0
107	10	2		1,8	5	2	0
108	7	4	6	1	14	2	0
109	7	3	1,2	3,4	0	2	0
110	10	1		5	0	2	5
111	10	2		2,6	9	2	9
112	9	7		5	5	2	3,6
113	9	2		1,2	0	2	0
114	9	1		6,7	0	2	0
115	9	3	1	3,4	13	2	0
116	8	1		1,2	0	2	5
117	10	2		5	1	1	1
118	10	7	14	3	11	1,2	0
119	10	2		9	0	1,2	1,9
120	10	5		6	5	2	7

ID	Importance	Importance in comparisson	Other important problem (Notes)	Most important topic?	Solutions	What can you do?	Any more comments
121	10	2		2	2,4,7	2	7
122	10	2		9	2,3	0	1,9
123	10	2		6,7	1,2,4,8	1,2	3,4
124	10	1		1	5	2	0
125	8	2		4,5	4,5	0	0
126	10	1		3	3	2,4	0
127	5	2		6	0	2	0
128	10	2		2	2	1	1
129	10	1		2,8	0	0	0
130	10	4	1	8	3	2	5,7
131	10	2		6	2	4	0
132	10	1		5	3	2	0
133	10	3	13	4	3	2	4
134	9	2		1,2	3	2	1
135	10	2		2,8	4	3,4	1
136	10	1		1,2	2	2	5,7
137	8	1		2	0	2	0
138	8	2		2	12	10	8
139	10	4	1	9	0	6	0
140	7	2		5	0	2	0
141	9	1		1,2,9	3	2	0
142	10	1		3,14	2,4,9	2,4	0
143	8	1	15	0	0	0	0
144	9	2		5	0	2	0
145	8	7		6	3	2	0
146	10	1		1,2	0	2,4	10
147	10	1		1,2,10	1	2	0
148	10	1		0	0	1,2	0
149	9	3	1	5	0	2	4
150	10	1		2,8	4	1,2,3	0
151	10	1		4,5	0	3	0
152	10	1		9	5	2	1
153	8	1		0	0	2,4	0
154	10	1		6,8	4	2,4	1
155	8	3		0	1,5	1,2,3	1
156	5	2		2	2	4	0
157	10	2		1,2	4	2,3	1,5
158	10	2		2	4	2,3,5	1
159	10	1		8	6,12	2,4	1
160	10	2		5	14	2	0
161	10	5	1	0	0	2	0
162	10	1		1,2,3	1,2	0	0
163	10	1		4,5,6,8	1,4,5	1,2	1
164	8	2		1	3	4	0
165	10	2		1,4,6,7,10	0	3	0
166	10	2		14	0	2,4	1
167	10	4	1	8	5	2,6	1
168	10	4	1,9	5	0	2	0
169	10	1		5	4	1,2	10
170	10	2		1	3,16	1,2	5
171	8	1		8	4	2,6	0
172	9	1		1,2	4	11	0
173	10	2	1	2,5	2	1,3	0
174	10	1		2	4	2	0
175	10	1		2,9	2,4,10	1,2	0
176	9	0		4	0	2	1
177	10	1		2,5	3	2	2,9
178	8	3		3,4,5	0	0	1,10
179	10	2		5	16	2,4	0
180	9	6		5	3	0	0
181	10	4	6,11	13	14	0	1
182	10	1		3,4,5	0	0	0
183	10	4	1	5,6,8	4,8,10	2	1
184	9	1		2,7	1,8,10	2	0
185	10	1		8,13	8	1,2,7	1,2,7,8,9,11
186	9	1		3,15	0	9	0
187	10	2		3,5	0	10	0
188	10	3	1	3,8	4,5,8	1,2,6	0
189	10	2	1,8	8	0	2	0
190	10	3	1,9,10	5	1	1,2	0
191	10	1		3,8	4,5	2	0
192	10	5		1	0	2	6

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